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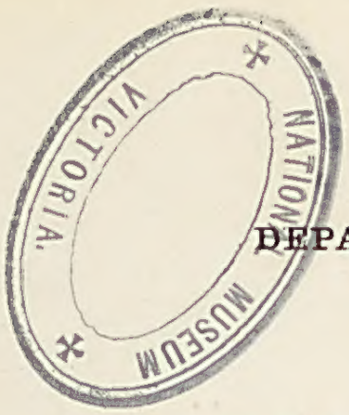

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Queensland Geological Survey.

B. DUNSTAN, Government Geologist.

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Geology and Mineral Resources

OF THE

Stanthorpe, Ballandean and Wallangarra Districts

(with Notes on the Silver Spur Mine, Texas),

Southern Queensland, 1913,

WITH 4 MAPS, 4 FIGURES, AND 23 PLATES.

BY

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GEOLOGY AND MINERAL RESOURCES

. . . OF THE . . .

Stanthorpe, Ballandean, and Wallangarra Districts

(With Notes on the Silver Spur Mine, Texas, Southern Queensland).

INTRODUCTION.

In view of the attention being directed to the Stanthorpe Tinfield recently as a result of the operations of dredging plants in that neighbourhood, and also the lode tin discoveries at Red Rock, Beehive, Carpenter's Gully, &c., at Ballandean, in the Stanthorpe district, advantage was taken of an opportunity to spend some weeks in the district noting the more recent developments of the field. The accompanying report will form portion of a monograph by the writer, dealing with Tin Mining in Queensland, to be prepared subsequently, as opportunity offers.

The present description of the field and the geological maps accompanying it were prepared to indicate the condition of the tin-mining industry of this district obtaining at the middle of the present year (1913), as previous observers had fully described in already published official reports the operations formerly conducted. Of these former reports the principal are:—

(1) "On the Geology of the country round Stanthorpe and Warwick, South Queensland, with especial reference to the Tin and Gold Fields and the Silver Deposits" (with maps, plates, and sections). By Sydney B. Skertchly, late Assistant Government Geologist; being Geological Survey of Queensland Publication No. 120; issued in 1898, and

(2) "Notes on Tin, Copper, and Silver Mining in the Stanthorpe District" (with 13 plates). By Lionel C. Ball, B.E., Assistant Government Geologist; being Geological Survey of Queensland Publication No. 191, issued in 1904.

As these reports fully describe the early tin workings it has been decided that *the following Report shall be restricted more*

particularly to a description of the present (1913) *aspect of the mining activity and a consideration of the essential geological factors governing the deposition of the commercially valuable metals occurring within the area*—viz., tin, wolfram, and molybdenite.

Though it is intended that the subsequent chapters dealing with the mining industry itself will form the *raison d'être* of the report, it has been deemed desirable to devote a certain amount of space to a scientific consideration of the host rocks themselves, as the permanency or otherwise of the stanniferous, &c., lodes is intimately bound up with the petrographical relationship of the various formations met with in the area under review.

The report is accompanied by a geological map of the Stanthorpe to Wallangarra district, in which the main geological and topographical features are portrayed with a fairly close approximation to accuracy in most cases; particular attention was paid to the accurate determination of the outcrops of the fine-grained acid granite (the "Sandy Granite"), as that formation, together with the aplitic granite and quartz-porphyry dykes, greisen and pegmatite veins, &c., are considered to be the main "ore-bringers."

For much useful information concerning the genesis of the metalliferous deposits, &c., I am indebted to the publications issued by Messrs. J. E. Carne, F.G.S., Assistant Government Geologist, and E. C. Andrews, B.A., F.G.S., Geological Surveyor, both of the Geological Survey of New South Wales. Having myself been associated in the field with Mr. Carne when an officer of the Geological Survey of that State, I am well acquainted with the majority of the stanniferous areas in the New England district referred to in his excellent monograph on the subject, viz., "The Tin-mining Industry and the Distribution of the Tin Ores in New South Wales," being No. 14 of the Mineral Resources Series; published in 1911. The important question of the genesis of the New England ore deposits was also dealt with in some very interesting papers contributed by Mr. Andrews to the Records of the Geological Survey of New South Wales; of these latter publications mention should be made in this connection of the following:—

1. "An Outline of the Tertiary History of New England" (Volume VII., Part III., pp. 140-216).
2. "The Geology of the New England Plateau, with special reference to the Granites of Northern New England,"

(Volume VIII., Part II., pp. 108-152), being Part II., General Geology, and Part III., The Genesis of the Ore Deposits. Parts IV., dealing with the Petrology, and V., Additional Notes on the Origin of New England Ore Deposits, appeared in Volume VIII., Part III.

For further information on the subject, attention is directed to two other instructive publications by Mr. Andrews, viz.:—

"Molybdenum" (1906) and

"Report on the Drake Gold and Copper Field" (1908); being Nos. 11 and 12 respectively of the Mineral Resources Series, New South Wales.

Subsequent to the publication of these reports, but prior to the issue of Mr. Carne's monograph, a paper styled "The Tin Deposits of New England" was contributed, in 1910, to the Linnean Society of New South Wales, by L. A. Cotton, B.A., B.Sc., Linnean Macleay Fellow of the Society in Geology. This publication contains much that will be found of interest to students of the phenomena associated with the genesis of tin deposits in Australia. During a considerable portion of the time he was engaged on the field work I was associated therein with Mr. Cotton. During the course of my examination of the New England tinfields for Mr. Carne, I made, *inter alia,* a geological sketch map of the northernmost area—namely, that district adjoining the Queensland border, of which Willson's Downfall is the centre. The geological map (No. 3) of the Stanthorpe district on the Queensland side of the border range, accompanying the present report, is in reality a continuation of the mapping of the rock formations shown in my Willson's Downfall-Maryland geological map abovementioned. With the object of showing that the Northern New England (New South Wales) and Stanthorpe (Queensland) districts constitute a petrographical and mineralogical province, a sketch map (No. 2) has also been prepared to illustrate the relationships of the formations and their contained metalliferous deposits. It is hoped that the publication of this combined information will assist towards elucidating some of the difficult problems associated with the scientific question of the granitic intrusions and also the more truly economic phase of ore deposition.

The continuation of investigations across the border line of two States by one observer constitutes a somewhat unique feature in the present geological examination, and indicates the

possibility of bringing to a more uniform basis the different locally adopted nomenclature applied to strata of undoubtedly the same age and character occurring in adjoining States.

As early as the year 1853, that great pioneer in Australian geology, the Rev. W. B. Clarke, reported upon the Pike's Creek district, and stated that in his opinion this district would prove to be auriferous.*

Another early geologist of great repute, Mr. S. Stutchbury, saw the Canal Creek area the same year, when engaged in examining the geological and mineralogical structure of New South Wales; he records the occurrence of slates and greenstones, and was successful in finding "colours' of gold.†

Some sixteen years afterwards (1869) two reports on areas in this region were furnished by Mr. C. D'Oyly H. Aplin, then Government Geologist for South Queensland.‡ He assigns a Silurian age to the slates, &c., occurring in that part of the State.

Perhaps the earliest report on the Stanthorpe Tinfield itself was that issued by Sir A. C. Gregory (late Government Geologist of Southern Queensland), entitled "On the Mineral Discoveries on the Head of the Severn River and its Tributaries"; published as a Parliamentary Paper in 1872; 2 pages. (Now out of print.) This report contains a description of the stream workings.

The same writer still seven years subsequently furnished a report‖ on the south-eastern portion of Queensland, in which he claims a Devonian age for the sedimentaries.

In addition to the foregoing, early references to this field will be found in the "Report on the Queensland Tin Field," by Walter C. Hume, then Mineral Lands Commissioner. This report was published as a pamphlet of 31 pages in 1874. The pamphlet contains a sketch geological map of the Stanthorpe district from beyond Mount Magnus in the north to Mingoola and the New South Wales border on the south, and westerly

* Geological Surveys. Letter from the Rev. W. B. Clarke to the Hon. the Colonial Secretary, on the Geology of the Basin of the Condamine River, Sydney: By Authority; 1853, pp. 2, 3.

† Geological and Mineralogical Surveys. Eleventh Tri-monthly Report by the Geological Surveyor, Sydney: By Authority: 1853, pp. 6-8.

‡ Progress Report of the Government Geologist for South Queensland, Brisbane: By Authority, 1869. Report on the Auriferous country of the Upper Condamine, embracing the "Diggings" at Talgai, Thane's Creek, Canal Creek, and Lucky Valley.

‖ Geological Features of the South-eastern Districts of the Colony of Queensland, Brisbane: By Authority: 1869.

beyond Pikedale. The map shows the area occupied by granite (which he subdivides into granite and "stratiform" granite), and the slates and volcanic rocks (undifferentiated). The report contains a description of the plutonic rocks, the stanniferous veins appearing at Kilminster, Lode Creek, Red Rock, &c., as also the sources of the alluvial tin and the relative age of the formations. For courtesy in enabling me to see this long since out-of-print pamphlet I am indebted to the Parliamentary Librarian; the pamphlet is bound in with others in "Miscellaneous Relating to Queensland," A 1 to 16. Several specimens collected by Mr. Hume were forwarded by him to the South Kensington Museum for examination.

On the 24th July, 1882, a two-page foolscap report* was furnished by Dr. R. L. Jack, formerly Government Geologist of Queensland, entitled "Stanthorpe Tin Mining District, Preliminary Report." The report (now out of print) was published as a Parliamentary Paper. This short report gives the author's ideas on the subject of the genesis of the tin ore. He also wrote a further report, published in the Annual Report of the Department of Mines for the year 1885.

On the 14th May, 1887, a five-page foolscap report, entitled "Glenelg and other Reefs in the neighbourhood of Thane's Creek and Talgai, and certain Mineral Deposits near Stanthorpe," was issued by Mr. Wm. H. Rands (late Assistant Government Geologist.† He deals with the tin-lodes at Nundubbermere, near the Severn River, &c.

In the year 1890 Mr. Rands again visited portion of the district, and his observations on the mining operations then in progress are embodied in a two-page foolscap report on "The Mineral Selections on the Ballandean and Jibbinbar Runs."‡ This report (now out of print) was published as a Parliamentary Paper, No. C.A. 12-1890. The same writer also published reports on the district in the Annual Reports of the Department of Mines for the years 1883, 1887, and 1900.

In 1895 Mr. A. Gibb Maitland, late Assistant Government Geologist, published a report dealing with certain gold mines on the Pikedale Goldfield.§

* G.S.Q. Publication No. 12.

† Brisbane: By Authority 1887, G.S.Q. Publication No. 40.

‡ G.S.Q. Publication No. 67.

§ Notes on the Pikedale Goldfield: Bulletin No. 2 G.S.Q. Publication No. 105, Brisbane: By Authority, 1895.

In the year 1907 Mr. Walter E. Cameron, B.A., Assistant Government Geologist, visited the area, and his report is contained in the Annual Report of the Department of Mines for that year, pages 170-1. Mr. Cameron gives an account of the Pikedale Mine, Sundown Tin Mine, Silver Spur Copper Mine, and the Queen Silver-Lead Mine at Ballandean; these reports were furnished in connection with applications for Government financial assistance in various directions.

Much information concerning the field has also been published from time to time in the "Queensland Government Mining Journal," issued by the Department of Mines; these reports consist largely of statistical information contained in the quarterly, &c., returns supplied by the Mining Wardens stationed at Stanthorpe. Mr. E. O. Marks, B.E., late Assistant Government Geologist, also published a report in that journal in November of last year (1912), in which he describes the occurrences at the Beehive and other properties at Red Rock, and gives numerous assay returns of samples taken by him.

A sketch map, showing the location of Stanthorpe, Ballandean, Wallangarra, &c., is included for the guidance of readers.

In order to the more clearly illustrate certain features of the Report, a series of photographic views showing especially the methods of dredging at present in vogue at Stanthorpe has been added.

It is not too widely known, even in Stanthorpe, that a good collection of the various minerals and ores found in the district are on view in a special room at the Mining Warden's Office at that town; this representative collection has been got together by the enthusiastic exertions of Mr. Stanley Wilson, who was until recently stationed there. These specimens were arranged and named by Mr. J. A. Smith, of the staff of the Queensland Geological Survey; the showcases in which they are exhibited were supplied by the Department of Mines, Brisbane. Prospectors and others interested in the different minerals to be found in this region would do well to avail themselves of the opportunity of examining this collection, as it has frequently happened in the history of mining that minerals of commercial value have been passed by as being of no import through ignorance of their composition. The tellurides of Kalgoorlie, Western Australia; the chloro-bromide in the oxidised portions of the Broken Hill lode; and the mineral cassiterite (tinstone) itself, of which this report is mainly concerned, afford well-known

instances of valuable minerals not being recognised as such until long after they had first been seen.

During my visit to Stanthorpe I was so frequently asked by miners and others as to the method of procedure to be adopted in forwarding samples of minerals to the Department of Mines for identification, &c., that I have deemed it advisable to add, as an appendix to this report, a copy of the leaflet issued by the Geological Survey Office, entitled "Testing Samples for Prospectors."

Acknowledgments.

During the major portion of the time in which I was engaged at Stanthorpe and the surrounding districts I was assisted in the field work by Mr. E. F. Eberhardt, of the Draughting Branch of the Department of Mines. To this officer's earnest co-operation is due the fact that I was enabled to carry out, within the limited time available, several hundred miles of traverses around the rock outcrops, with a reasonable approach to accuracy. The geological maps which accompany this report have been prepared for Press by him.

I desire to express my thanks also to Messrs. S. Wilson, the late Mining Warden at Stanthorpe, and T. R. Kennedy, the present occupant of that office, for their courtesy and ever-ready assistance in affording information concerning the mines, &c.; also to the various dredge masters and the miners generally for kindly help in various ways.

Location, &c.

The township of Stanthorpe is within extremely easy reach of either Brisbane or Sydney, being situated on the main line of railway uniting these capitals, at a distance of 207 miles south-west from the former city and 26 miles northerly from the railway town of Wallangarra, on the New South Wales border. Height above sea level at the Stanthorpe Railway Station, 2,656 ft. (according to the railway survey).

Its location may be taken as being in approximately latitude 28° 35′ south, longitude 152° east, county of Bentinck, Darling Downs District.

The technical description of the Stanthorpe Mineral Field, as given in the "Queensland Mineral Index (1913)" is appended:—

Proclamation of Field.—First (and only one), 3rd January, 1883, as follows:—Commencing at the junction of Canal Creek with the Broadwater, and bounded thence on the north by a line bearing east to the Condamine River upwards to the confluence of Clifton Creek; thence by the range dividing the waters of Clifton Creek from those of Dalrymple Creek north-easterly to the Main Range; on the east of the Main Range southerly to the south boundary of the colony of Queensland; on the south-east and south-west by that boundary westerly to the confluence of the Macintyre Brook with the Macintyre or Dumaresq River; on the west by a line north to the range dividing the waters of Macintyre Brook from those falling into Weir River; thence by that range north-easterly to Mount Domville or Wilmeran; thence by a spur to the junction of Broadwater with Canal Creek, the point of commencement.

The official duties of mine inspection are carried out by Mr. W. E. Lawrie (stationed at Ipswich).

CHAPTER I.

HISTORY OF THE FIELD.

The first authentic record of the presence of tinstone in this region refers to the discovery of alluvial tin in the year 1854 by a Mr. Joseph Greer on Nundubbermere Run, though a specimen was forwarded to England for examination the previous year. The discovery of payable tin ore in this locality did not, however, eventuate till eighteen years afterwards, when Paddock Swamp, a branch of Quart Pot Creek, and Four-mile Creek, alluvial claims, were opened in February, 1872. In his excellent monograph on the New South Wales tinfields,* Mr. J. E. Carne, Assistant Government Geologist of New South Wales, makes the following reference to the subject:—

> "Discovery of payable tin ore at Quart Pot Creek (now Stanthorpe, Queensland) followed shortly after the Elsmore [N.S. Wales, E. C. St. S.] discovery, Mr. C. S. McGlew again being chiefly instrumental in its announcement. A clue had been given him by Mr. G. W. F. Addison, Police Magistrate, whose interest, stimulated by the rich finds at Elsmore, revived recollection of a very weighty sandbag used as a windbreak at the Quart Pot Hotel. It was found that the source of the filling was the adjacent creek bed.
>
> "Mr. McGlew and his partner, Mr. Eisenstaedter, acting on the presumption that the heavy sand might contain tin, at once proceeded to the locality, and immediately proved the correctness of the surmise; this being probably the first discovery in Queensland territory. The first report on Queensland Tin Discoveries (by T. F. Gregory) was read before the Geological Society 6th November, 1872."†

Judging by the officially recorded output, during the first decade of its existence (1872-1882), the Stanthorpe tinfield gave up to its then very numerous body of alluvial miners an exceedingly disproportionate amount of the tinstone won during the period that has elapsed since its discovery; during the period mentioned the yield reached the great total of 8,938 tons during

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* "The Tin Mining Industry and the Distribution of Tin Ores in New South Wales." Being Mineral Resources Series No. 14, 1911, page 20.

† Quarterly Journal of the Geological Society, Vol. XXIX., 1872, pp. 1-5.

the year 1873, showing a gradual decrease till 1882, by which time the returns had diminished to 2,451 tons. The subsequent year (1883) witnessed a remarkable falling off in the output, only 817 tons being won. The period of greatest stagnation in the industry was that from 1895 to 1901, inclusive, during which time the annual yield failed to reach even 100 tons, the minimum output being witnessed in 1897, when the insignificant amount of 53 tons was obtained. The somewhat improved yields now being annually recorded are, of course, the direct outcome of the dredging operations now being carried on, and but for which the output would be hardly worth considering.

Referring to the question of the early history of the field, it is of interest to record that, in addition to the claims opened at Paddock Swamp and Four-mile Creek abovementioned (in February, 1872), tinstone was proved to exist in Broadwater River during the month of June, the same year. The first mineral selection officially recorded for tin-mining was that taken up on Spring Creek on the 22nd April, 1872. For this and other statistical information I am indebted to Mr. B. Dunstan, Government Geologist, who kindly placed at my disposal the information which is being published in his comprehensive Queensland Mineral Index.*

For the benefit of those residents of Stanthorpe who are interested in the early history of their town, it has been thought desirable to reprint portion of a report furnished by Mr. Pollet Cardew, then Mineral Land Commissioner, which appeared in the Annual Report of the Department of Mines for the year 1887 (now out of print). Mr. Cardew thus describes the condition of affairs obtaining at that time:—

REMINISCENCES OF THE EARLY DAYS.

Prior to the year 1872 Stanthorpe was not in existence. Where the township now stands there was a sheep-station belonging to the old Folkestone Run, with a single bark hut on the bank of the creek, but which now goes by the charming appellation of Quart Pot Creek, owing to the simple fact of the manager of Maryland (an adjoining station) having one day lost his quart pot at the crossing there. In the month of April, 1872, when the big rush to the newly-discovered tinfields commenced, Cobb and Co.'s coaches ran twice a day from Warwick, which was at that time (and for many subsequent years) the terminus of the Southern and Western Railway Line. These coaches were always overloaded, yet hundreds of men tramped to the spot. The scene at the new township reminded one of an English country fair in days gone by. Flags floated in the breeze above the various tents and huts of bark, with goods of all kinds exposed for sale around them; while eager would-be miners bought readily of the supplies, tools, etc., thus displayed before them.

* G.S.Q. Publication 241.

The principal hotel (so-called) consisted of one large apartment with wide benches fixed all round the walls and spread with straw and blankets for the accommodation of lodgers.

The post office—a store and "shanty" combined—was kept by a worthy son of Erin, who delivered the mails in a novel manner, viz., by mounting a cask and calling out the names of those to whom the letters were addressed, when such owners of the same as were present pressed forward to receive them.

One old landmark has disappeared with the progress of civilization—namely, the "Roll-up tree," a forest king which was standing alone in the middle of the main street, opposite Pat Tevlin's Hotel. Around this tree the miners met at night, and it was a silent witness of much varied eloquence, as there they crowded to discuss their good luck or grievances, as the case might be, warmed and lighted by a huge wood fire, to which each comer was expected to add a log or so. This tree, however, was destroyed some time afterwards, when political rancour ran high, by burning the late Honourable Ratcliffe Pring in effigy.

The first commissioner (F. T. Gregory) was appointed and came to look after the district in April, 1872. He was afterwards succeeded by W. C. Hume, who was withdrawn in May, 1875, when the duties of the land commissioner were transferred to the police magistrate.

In June of the abovementioned year the police magistrate at Charleville (Warrego) was appointed the first police magistrate of the newly-formed yet flourishing township, which was now given the very suitable name of Stanthorpe. Here the police magistrate literally "pitched his tent," holding his courts in a tent occupied by the sergeant of police, the bed serving for a "Bench" and a table; and in this primitive fashion the law was administered for some time, the only way of securing a prisoner being to chain him to a tree until a temporary lockup was manufactured and forwarded from Brisbane; subsequently a better one was erected, and also a good court-house. A Masonic and Oddfellows' hall have also been built, where public meetings are now held instead of in the precincts of the "Roll-up tree," as in the earlier days. Several neat hotels also afford shelter to travellers, and the wild days of this "tin town" are things of the past. Indeed, one would scarcely recognise in the now neatly-built village town the original haphazard looking place of but sixteen years ago [1872], with its tenements of canvas and bark, and its ever-shifting population; while now [1888] substantially built houses and cottages, surrounded by their neatly kept gardens, testify to a settled population, who may justly look forward to increasing prosperity as the tin and silver mines become further developed. In May of the year 1883, the railway was extended from Warwick to Stanthorpe, which of course drove Cobb's coaches out of the district. The journey of forty miles by train was a decided improvement, but the trains brought mosquitoes here, which were hitherto unknown at Stanthorpe. This is a fact, as these tormenting insects took shelter in the carriages and vans, at the southern (or rather eastern) stopping places, and were so brought on, but are pretty well kept in check by the hard frosts enjoyed here each winter. In January of this year (1888), the railway has been extended to the border of New South Wales, meeting the line from Tenterfield at Wallangarra, about twenty-four miles from Stanthorpe. This affords an overland route to Sydney, which journey can be accomplished now in twenty-four hours. (Distance 518 miles, journey now [1913] accomplished in about 18 hours. E. C. St. S.)

CHAPTER II.

METEOROLOGY.

Even a quarter of a century ago it was fully realised that the climate of Stanthorpe made that locality an ideal situation for a health resort, &c. Mr. P. Cardew, Mineral Land Commissioner, in his annual report to the Department of Mines,* made a prophecy which subsequent happenings have completely fulfilled; in the concluding paragraph of his report he says:—

> "There cannot be any doubt that the town of Stanthorpe and surrounding district will in the course of time become the inland sanitorium of Queensland, when the hills commanding magnificent views will be studded with comfortable and pretty villas with enchanting gardens, for not only do most fruits flourish here, but also all the English flowers and shrubs grow and flower to perfection, thus evidencing the cool and salubrious climate of this richly gifted district."

The following table, giving the official monthly average weather returns for the Stanthorpe district, has been kindly supplied to me by Mr. H. A. Hunt, Commonwealth Government Meteorologist; the figures quoted, representing the averages of many years, may be taken as indicating the meteorological conditions normally obtaining in that district. It will be noticed that the heaviest rainfall is recorded during the summer months, January being usually the wettest and April the driest month of the twelve. The mean maxima temperature for the hottest month, January, being only about 80 degrees, it can be readily understood that the climate of Stanthorpe is delightful during the summer time. The winter climate is also exhilarating in the extreme. Frosts occur nearly every night during the winter months; in fact, the writer has seen quite as severe frosts at Stanthorpe as on the southern tablelands of New South Wales or in Tasmania. Orchardists in this district welcome a continuance of frosts through the winter months, as such phenomena tend to prevent the great loss arising from the spoliation by severe late frosts, following on a mild spring-like winter, of early-forming fruit.

Several light falls of snow have occurred within the area embraced by the accompanying geological map (No. 3); this is

* Annual Report of the Department of Mines, Queensland, for the year 1887, p. 79

in no wise remarkable, seeing that the average elevation above the sea level is about 3,000 ft., ranging from a little above 1,000 ft. to over 4,000 ft.

Monthly Average Temperature, Rainfall, and Humidity at Stanthorpe.

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
				TEMPERATURE.								
				Mean of Maxima for 15 years.								
80·1°	78·2°	74·5°	69·6°	63·8°	57·6°	56·0°	59·8°	65·7°	73·2°	77·2°	80·7°	69·7°
				RAINFALL (Points *)								
				Means for 23 years.								
400	327	348	155	171	185	196	169	231	264	293	346	3085
				9 A.M. HUMIDITY.								
				Means for 13 years.								
66%	70%	71%	72%	76%	78%	75%	69%	63%	59%	60%	60%	68%

* 100 points of rain equal 1 inch.

CHAPTER III.

PHYSIOGRAPHY.

The topographical forms developed in the district under review are essentially those resulting from the denudation of granite mountains in temperate climates with a moderate rainfall —namely, an elevated tableland on which numerous hill ridges occur between rather broad open valleys, through which shallow streams find their way.

In many places the border range separating New South Wales and Queensland is hardly perceptible, though at times it becomes steep and almost impassable; *e.g.*, the neighbourhood of Bald Rock and Wallangarra. The highest peak in the area is Mount Norman (in the Wallangarra district), which attains an altitude of 4,066 ft.; this peak, which is situated in latitude 28° 51′ south and longitude 151° 57′ east, is a trigonometrical station, as is also Mount Magnus, 3,206 ft. high, situated some 12 miles to the north-east of Stanthorpe. A short distance to the north-east of Mount Norman occurs a high peak, known as Castle Rock, whilst still further eastwards in the same neighbourhood, and attaining a hardly less altitude, are seen Bald Rock and that peculiar grooved mass of granite which has been well named "The Pyramids" by Mr. E. Long, of Wallangarra. Tourists who visit the Stanthorpe district should not fail to see these spots, the sight of such giant (600 ft. high) masses of bare rock being awe inspiring to a degree, and certainly quite as fine as many other much-advertised places beyond the State.

In the immediate vicinity of the township of Stanthorpe are several well-known hills—viz., Mount Bancа, Mount Marlay, Bald Rock, Lees' Hill, Blue Mountain, Mount Tully, &c., the positions of which have been indicated on the geological map of Stanthorpe.

Taking the district as a whole, it may be said that the most marked weathering and denudation of the rock masses has taken place along their northern sides, in this respect resembling the southerly New England (New South Wales) tin granites.

A characteristic feature of this district is the very numerous, and at times extensive, holes in the hard granite stream-beds, notably along the Broadwater and Severn Rivers. Similar

eroded holes at one time were found along the Quart Pot Creek, but alluvial mining operations have since caused them to be filled up with sand, gravel, &c.*

At many places throughout the area occupied by granite rocks are to be seen good examples of the characteristic "balanced rocks" (tors), which have been brought about by the weathering of jointed blocks of stone. For some not properly understood reason connected with the internal structure of granite rocks generally—and particularly the case with the coarser varieties as far as Stanthorpe is immediately concerned —effects best likened to the gradual peeling of some giant onion are produced by weathering. This process is termed "exfoliation" by geologists; it continues to act till the rocks assume a rounded appearance, in which case they are often mistaken for water-worn boulders. Where one block resting upon another has been subjected to the agencies of sub-aerial denudation, with the production of such an exfoliated boulder, the resulting structure is called a "tor"; at times three and even four such blocks, each resting on a comparatively small base, are seen. The results of the phenomenon of exfoliation are well seen at "The Caves" and the "Balanced Rock," two spots close to Stanthorpe frequently visited by tourists (*vide* Plates 4, 5, 6).

In the Red Rock area we have an example of extreme youthful age of the stream, Red Rock Creek having carved out a precipitous gorge through the slates to a great depth into the underlying granite intrusive; the stream now enters the gorge by way of a waterfall some 150 ft. in height, the cliff face corresponding with a set of master-joints.

The heads of many of the gullies and streams consist of more or less extensive marshes, similar to those seen throughout New England, of which latter tableland, indeed, the Stanthorpe area forms but a part.†

The accompanying photograph of the township of Stanthorpe (plate 1) gives a fair idea of the characteristic topography of the granite country.

Mr. Walter C. Hume‡ mentions the existence of caves at Glenlyon, between Stanthorpe and Texas, extending for several hundreds of yards through the limestone belts.

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* C.f. Deepwater River, New England, N.S.W.

† This belt of elevated country stretches from Tamworth in New South Wales to Warwick in Queensland.

‡ "The Queensland Tinfield," 1872, p. 13.

PLATE 1.—MAIN STREET OF STANTHORPE, LOOKING SOUTH. *[Photo. L. Jobson*

Shows characteristic topography of granite country in background.

CHAPTER IV.

GENERAL GEOLOGY.

The topographical features referred to in the aforegoing are the natural results of denudation upon certain rock types. The following table is an attempt to classify in geological sequence the thirteen various members comprised within the Stanthorpe (Queensland)-Willson's Downfall (New South Wales) petrographical and mineralogical province.

CLASSIFICATION OF THE STANTHORPE-WILLSON'S DOWNFALL ROCKS.

POST TERTIARY.

Recent.

(1.) Granite *sand, clay, gravels, and rubble*; occurring along the present stream channels, in swampy flats and the marshes at the heads of streams.

Usually *stanniferous*, and frequently with topaz, and, very rarely, diamonds, sapphires, and rubies, &c.

Pleistocene (*?*).

(2.) Coarse semi-waterworn *gravels, red clay, &c.*; the gravels consisting largely of cairngorm; usually rather thin deposits along high ground; cemented on the surface by oxide of iron.

Frequently contain a little waterworn *tinstone* and gold (especially near Maryland).

TERTIARY (?).

(3.) Dykes of *diorite, mica-lamprophyre, basalt, dolerite, &c.*

Non-stanniferous, but frequently intimately associated with gold, silver, lead, zinc, and copper deposits.

MESOZOIC (?).

(4.) Dykes of *rhyolite, quartz-felspar-porphyry, quartz-porphyry, and aplitic granite; greisen* seams and *pegmatite* veins.

Stanniferous; also contain small quantities of wolfram and molybdenite.

(5.) *Fine-grained acid granite* (*the "Sandy" Granite*): yields a poor soil and supports a stunted vegetation; pink-coloured; consists of an even-grained admixture of quartz and felspar with numerous specks of biotite.

Stanniferous; frequently also wolfram and molybdenite-bearing.

(6.) *Coarse-grained acid granite* (*the "Stanthorpe" granite*); pink to grey in colour; produces fair soil; forms "tors."

At times *stanniferous.*

(7.) *Porphyritic granite,* giant crystals of felspar (mostly orthoclase), with macroscopic sphene and numerous large basic segregations; at times closely approaches to a diorite in composition. Produces good grazing land. May possibly be a modification of the "Stanthorpe" granite (6).

Non-stanniferous, and not known to be genetically connected with other metals of commercial value.

(8.) *Biotite granite* (*the "Maryland" Granite*); tendency to form "tors"; small basic segregations common; a medium-grained rock with abundant quartz and mica; produces good grazing land and reddish soil. Belongs to the type named "*Adamellite*"; does not occur on the Queensland side of the border within the area mapped.

Non-stanniferous.

PALÆOZOIC.

PERMO-CARBONIFEROUS.

Upper Bowen (?).

(9.) *Micro-granite, dacite, quartz-porphyry* (*the "Blue Granite"*); yields good red soil produces fairly level country covered by good timber. Characteristically blue in colour. Biotite abundant.

Non-stanniferous.

Lower Bowen.

(10.) *Marine slates* (rarely fossiliferous); *tuffs, conglomerates, limestones, shales, sandstones, and volcanic breccias.* Locally known as "Trap." Produces rough hill ridges rendering travelling difficult.

Rarely *stanniferous,* except along its contact with the intrusive acid granites where good deposits occur (*e.g.,* Red Rock). Numerous gold, silver, lead, zinc, and copper lodes (*e.g.,* Silver Spur).

PRE - PERMO-CARBONIFEROUS.

(11.) *Acid grey felspar porphyry*; probably a lava flow. A yellowish to white slatey rock producing light-coloured clayey soil with fair timber and grass; forms very rough ridges (*e.g.,* Donnybrook) and at times undulating country. Frequently has a mottled appearance. Locally included in the rocks called "Trap." Varies from a devitrified rhyolite to a micro-granite in texture.

Non-stanniferous; contains several barren white quartz reefs near Wallangarra.

(12.) *Altered diorite, grano-diorite, hornblende-granite, quartz-diorite, augite-diorite, mica-diorite.* Produces good red soil; occurs mostly in the form of isolated hills (*e.g.,* Baker's Hill, Maryland). A bluish to black rock. Seen only on the New South Wales side of the border.

Non-stanniferous.

(13.) *Granulite*; a rock highly altered by crushing and partial recrystallisation; exhibits cleavage planes and schistosity much resembling a

stratified rock. Probably originated from the extreme alteration of slates and quartzites. Produces a light-coloured rather clayey soil carrying good grass and timber. Included in the rocks locally named "Trap." Usually a dense blue rock, at times resembling a basalt.

Non-stanniferous (with the exception of a small tin vein at Quarry Hill, Maryland).

POST-TERTIARY.

Recent.

The deposits belonging to this age are, as shown on the accompanying geological map, of comparatively limited extent, though they are by far the most important from the viewpoint of the tin-miners, as they have afforded practically the whole of the stream tin mined in the district. They are composed of granite-derived sand—usually only party waterworn; sub-angular to well waterworn pebbles of white quartz, angular fragments of aplitic granite, odd boulders of diorite, fragments of slate, &c., white, yellow, and reddish clays, black mud, drift-wood, &c.

In view of the limited time at my disposal, only areas known to be or have been stanniferous were examined and mapped, other non-stanniferous areas—*e.g.*, the heads of certain streams, marshy flats, &c., belonging to this formation have not been taken cognisance of.

In addition to tin, of which mineral over two and a-half millions sterling worth have already been won, these deposits have yielded a few diamonds, sapphires, beryls, and tourmalines, and in places much topaz. The average depth of the stanniferous alluvium is about 6 ft., varying from a few inches to as much as 20 ft.

The granitic sand and clay are frequently bound tightly together into a rock-like substance known locally under the excellent name of "cement"; this material has here, as on many of the New South Wales tinfields, given much trouble to dredging plants, frequently necessitating the use of explosives. "Cement" has also in the past been often mistaken for the true granitic bedrock; the finding of alluvial tin wash under a stratum of this quasi-rock has led to the use of the miners' term "false bottom" in reference to it. The occurrence of this material has, however, been of great assistance to many fossickers, as it provides a good cover, thus enabling the wash-dirt sandwiched in between the

"cement" and the true granite bedrock to be taken out without removal of several feet of unpayable overburden in the first instance.

Odd specks of gold have been found during sluicing operations. Much black sand is found with the tinstone in the streams draining areas of "Stanthorpe" granite, whilst monazite sand also occurs in the concentrated alluvials fairly frequently.

Pleistocene (?)

The deposits comprised under this heading consist largely of partly water-worn crystals of smoky quartz, granitic sand, and red clay. They have been provisionally assigned to a Pleistocene age owing to their location on the tops of ridges well above the present stream channels. The depth of material of which this formation is composed is usually much greater than in the case of the Recent deposits just described, the greatest depth recorded from the New South Wales side of the border being 18 ft., which is also about the maximum depth on the Queensland side of the range. Its greatest development is seen along the border range between New South Wales and Queensland, especially in the neighbourhood of the Ruby Creek Road Gate on the Tick Fence; this area is known as Stormer's Ridge. The tin from these deposits is usually well waterworn and black in colour, accompanied by a fair amount of black sand (mainly ilmenite).

Especially in the neighbourhood of Maryland and Thulimbah these alluvia have yielded small quantities of waterworn gold, but not in sufficient quantity to yield payable results *per se*.

Small patches of this formation are to be seen along the ridge followed by the Rabbit Proof Fence to the west of the railway line some four miles to the north of Thulimbah. Here, as elsewhere, the upper surface of the deposit has been cemented by hydrous oxide of iron, giving it a characteristic red-brown appearance, which, however, is not usually apparent at a depth of over 6 inches from the surface.

The existence of this material, especially in the Stormer's Ridge area above quoted, has only been revealed by accident during mining operations, the surface of the ground being covered by typical sand from the "Sandy" granite to a depth of a couple of feet.

No work has been done on these deposits during recent years, but a considerable number of shafts were sunk some years ago.

Judging from the material comprising the newer Recent deposits, this older series of gravels and clays has contributed in

no small degree to the stanniferous deposits along the present stream channels. As the latter alluvia, therefore, represent, in part, a reconcentration of pre-existing stanniferous detritus, it is not to be expected that the remnants of these older (Pleistocene?) gravels, &c., will yield tin as abundantly as did the Recent deposits.

With the exception of certain obscure leaf remains resembling *Eucalyptus*, no fossils have been met with hitherto in any of these now isolated fragmentary deposits.

The boundaries of this formation are mostly hidden by Recent granitic sand, hence their delimitation on Maps 2 and 3 is but an approximation, based largely on the evidence furnished by prospecting holes, gravel waste, and soil. The western side of the Stormer's Ridge area will probably be found to be fairly correct, as the granite on which it lies outcrops as rocky knobs a short distance to the west of certain prospecting holes known to have bottomed on this formation.

No deposit belonging to this series has been seen by the writer in any part of the area examined other than those lying to the north and north-east of the township of Stanthorpe, along the summits of the Main Dividing Range and its spurs.

The absence of facilities for sluicing has in addition to the generally low tin contents, and the frequently prohibitive depth of the overburden overlying the tin-bearing wash-dirt, also operated against the working of these deposits for their valuable metals.

TERTIARY (?).

Basic Dykes.—The rock formations classified provisionally under this heading are comprised under the names of intrusive dykes of basic to intermediate composition, including diorite, mica-lamprophyre, basalt, dolerite, &c. Though no absolutely conclusive evidence has as yet been adduced to enable these igneous rocks to be assigned to a Tertiary age, it is practically a certainty that they do actually belong to that geological era. They can everywhere throughout New England and Southern Queensland be seen to intrude granitic rocks of almost certainly Mesozoic age, and in addition are generally considered to be closely connected with the great basaltic floods that deluged portions of these regions in Tertiary times. As regards the age of the latter volcanicity there remains no doubt whatever at present as regards New England, as abundant plant remains have from time to time afforded definite palæonotological evidence of the age of these strata.

Several samples of these *Post-Granitic* dykes were selected by me for petrological examination in 1911, and of these, Mr. G. W. Card, A.R.S.M., Petrologist to the Geological Survey of New South Wales, reported on two samples as follows:—

Diorite.—Sample from Maryland Common (close to the Queensland border, parish Maryland, county Buller). Under the microscope, "Made up of hornblende and plagioclase, the former slightly predominating. A little biotite and magnetite. The hornblende is all pale green in colour, and seems as if it might be in large part secondary. Shreds of hornblende are abundant as inclusions in the felspar."

Mica-Lamprophyre (*Minette*).—Sample from the Bookookoorara River. A fine-grained rock, breaking with a sub-even fracture. Under the microscope, "The constituents seen are orthoclase, plagioclase, hornblende, biotite, augite, and considerable quartz. Most of the minerals show a tendency to automorphism—that is, to assume their characteristic crystalline forms."

Mr. E. C. Andrews* obtained a sample of diorite from the wall of the Amalgamated Lode at Rivertree, to which dyke he refers as being "a compact grey diorite, showing bleached biotite and hornblende under the microscope."

A point of great present interest regarding these latest phases of igneous activity in the Stanthorpe district is their proved close connection with several ore deposits, notably at Rivertree; the occurrence of diorite dykes in close proximity to the Silver Spur Mine has also been suggested as being genetically connected with the ore-bodies there. It was noticed by the writer in 1911 that small quantities of gold were obtained in the Willson's Downfall area from alluvial deposits close to diorite intrusions. The ores mostly found associated with these dykes are those of gold, silver, lead, zinc, and copper.

Several dykes were seen in the area mapped (Map No. 3), by far the most numerous being the group of anastomosing intrusions into slates immediately below the Sundown mining area. In the last-mentioned district these basic dykes are mostly situated in juxtaposition to an important bluff-like outcrop of a quartz-porphyry dyke. In my opinion, the frequent existence of basic dykes in company with acid dykes of rhyolite, quartz-porphyry, and aplite in various portions of New England has more than a passing significance, representing very possibly a

* Records of the Geological Survey of New South Wales; Geology of New England Part 3, page 23.

series of complementary magmas belonging to the final stages of extrusion from the original molten rock which provided the materials for the great post-Carboniferous granite invasions. The dykes at this locality are rather coarser grained than usual and vary in mineral composition through nearly the whole range of igneous rock composition, samples that would be classified variously from a gabbro up to a hornblende granite being seen.

Numerous small dykes of diorite are to be seen invading the "Stanthorpe" (coarse acid) granite on a "saddle" on the north-eastern slope of Lees' Hill, about 2 miles south of the township of Stanthorpe. The dykes in this instance have no very persistent strike, but radiate out apparently from a common knot-like central mass; however, the occurrence as a whole may be said to have a general strike of about E.10°N., which corresponds approximately with the general north-east strike of the cleavages of the host rocks. The average width of the individual diorite veins is about 1 ft. The occurrence here is identical with that frequently observed by the writer in New England; the outcrops produce rounded boulders, which on being struck with a hammer readily split into similarly rounded fragments along lines of weakness in the form of iron-stained cleavage cracks; these cleavages appear to have had an origin comparable in the main to the "onion-coat" exfoliation of the surrounding granitic rocks. The rock fracture is sub-even; colour blue to dark green. Occasional small angular fragments of coarse granite are visible along and immediately within the periphery of the dykes, having clearly been disrupted from the enclosing wall rock during the upward passage of the semi-plastic basic magma. Practically no alteration of the adjacent wall-rock is to be seen; this feature is characteristic likewise of similar dykes elsewhere.

Another basic dyke belonging to this series occurs on the Severn River, on Portion 535, Parish of Marsh: the strike of this intrusion is parallel to those just described—namely, E.10°N.: width about 3 ft.

Still another identical dyke is found at the south-east corner of Portion 316, Parish of Broadwater; this occurrence is about 20 ft. in width and presents clear proof of its relatively late age as compared with the granites, as it cuts clear across an aplitic granite dyke.

Mr. Skertchly* records a dyke "of dioritic rock, breaking through the granite, running north 40 degrees east, or in the same general direction as the elvans, master-joints of the granite, and the cleavage of the slates."

* G.S.Q. Publication No. 120, page 40.

Mr. Walter C. Hume records a basalt dyke at a point 1½ miles S.E. of Ballandean Head Station; strike north-east; intruding granite.†

Speaking generally, the development of these post-granitic basic dykes is greater in the area occupied by slates than in the granite portions of the district; this may, however, be more apparent than real, owing to the relatively greater amount of alluvium and regolith obscuring the igneous outcrops as compared with the well-exposed outcrops on the usually rough and often precipitous hills produced by denudation of the sedimentary formations.

In addition to the before-mentioned two localities on the New South Wales side of the border from which the specimens microscopically examined were obtained, numerous dykes are to be seen; for the purposes of further study of these formations, students are advised to see the good outcrops presented by dykes along Herding Yard Creek, the Willson's Downfall to Tenterfield Road, and the Severn River.

A dyke of diorite striking S.S.W.-N.N.E. can be seen intruding the coarse granite close to the No. 1 Sugarloaf Dredge, Sugarloaf Creek; this dyke becomes split up at its northerly end, where its total width is 1 ft. It is of interest in that small amounts of gold—apparently shed from it—have been found here.

So far as I am aware these dykes, although they can be shown to be directly connected with the genesis of certain metalliferous deposits as stated above, appear to have had no influence whatever on the stanniferous, wolfram, and molybdenite deposits in this district; a subsequent chapter will show that the latter deposits were formed at a period prior to the intrusion of the basic dykes.

At Oakey Creek, near Copeton, in New England, a diamond was found by Mr. A. Pike *in situ* in a dolerite dyke of Tertiary? age, intruding a very coarse granite. As Professor T. W. E. David, Lecturer in Geology at the Sydney University; Mr. E. F. Pittman, Government Geologist of New South Wales; and other geologists, consider that the dolerite is the actual matrix of the gem in the Oakey Creek occurrence, the presence of occasional diamonds in the Stanthorpe-Willson's Downfall areas may well be referrable to a similar basic dyke-rock origin.

† Report on the Queensland Tinfield (1872).

Regarding the close association of lamprophyric dykes with the occurrence of mineral deposits, it is of interest to note that Mr. A. M. Howitt, in his recently published report on the Maryborough (Victoria) Goldfield,* draws attention to the occurrence of these basic dykes intruding strata of Ordovicean age in the area dealt with in his report. He states that these intrusions have had a great influence on the quartz reefs and their mineral contents (gold in this instance mainly).

A typical sample of a lamprophyre dyke (also seen by the writer) was obtained by Mr. Andrews from Bookookoorara Falls, Undercliffe, near Willson's Downfall. As its composition is practically identical with that of the majority of the dykes of similar age in the adjoining Stanthorpe district, the accompanying analysis of the specimen in question, carried out by Mr. J. C. H. Mingaye, Chief Chemist to the Geological Survey of New South Wales, is of value.† It will be noticed that an appreciable quantity of antimony is present, and as similar dykes of mica lamprophyre are associated with the antimony deposits at Hillgrove and elsewhere in New England, subsequent chemical and field examinations may result in definite genetic connection concerning the relationships of such rocks to the metal named being established.

CHEMICAL COMPOSITION OF LAMPROPHYRE DYKE.

	Per cent.
Silica (SiO_2)	47·84
Alumina (Al_2O_3)	16·23
Ferric oxide (Fe_2O_3)	4·18
Ferrous oxide (Fe O)	7·20
Magnesia (Mg O)	5·85
Lime (Ca O)	7·33
Soda (Na_2O)	3·57
Potash (K_2O)	1·11
Water at 100° C	0·70
Water over 100° C	2·90
Carbon dioxide (CO_2)	0·19
Titanic dioxide (TiO_2)	2·15
Zirconia dioxide (ZrO_2)	Absent
Phosphoric anhydride (P_2O_5)	0·47
Chlorine (Cl)	0·02
Fluorine (F)	Absent
Ferric disulphide (FeS_2)	0·35
Chromium sesquioxide (Cr_2O_3)	Absent
Nickel and Cobalt protoxide (Ni O and Co O)	Absent
Barium oxide (Ba O)**	Absent
Strontium oxide (Sr O)	Trace*
Lithia (Li_2O)	Present*
Vanadic oxide (V_2O_3)	0·01
Copper oxide (Cu O)	Trace
Antimonious oxide (Sb_2O_3)	0·04
Manganese oxide (Mn O)	0·29
	100·43

* Spectroscopic reaction only.

.The specific gravity was determined as 2·820.

* Memoirs of the Geological Survey of Victoria, No. 11, pp. 19, &c.

† Records of the Geological Survey of New South Wales. New England Geology, Part 3, p. 43.

MESOZOIC (?).

Rhyolite, Quartz-Porphyry, Quartz-Felspar-Porphyry, and Aplitic Granite Dykes; Greisen Seams, and Pegmatite Veins.

The intrusive igneous rock formations comprised under this heading are by far the most important and instructive in any consideration of the genesis of the tin, wolfram, and molybdenite deposits of Stanthorpe and New England. They constitute an "end-result" of magmatic differentiation, representing as they do a rock series formed as a final product from the original Post-Permo-Carboniferous granitic magmas referred to subsequently in the descriptions of the "Sandy," "Stanthorpe," and other granitic masses.

The exact position in geological time at which these acidic injections took place has not yet been definitely determined, but in all probability they may be assigned to a Late-Mesozoic age. It is fairly well demonstrated that they were formed at a time closely following upon the consolidation of the fine-grained acid ("Sandy") granite; indeed, it is practically certain that in many instances these dykes—notably the aplitic granite ones—formed part and parcel of the "Sandy" granite, of which they may be considered as forming still more acid apophyses.

From a great number of field observations it has been proved that the rhyolite and quartz-porphyry dykes are of mostly later age than the other members of the series, though at times there is complete evidence available to show that they have been formed contemporaneously with the aplitic veins into which they merge by insensible gradations in some instances. The era which witnessed this stage of magma differentiation belongs to that designated the

Euritic Period.—It represents the final scene in the great drama of the granite invasion, when the residual highly siliceous magma, accompanied by the original tin, tungsten, molybdenite, and bismuth contents, was introduced into the cooling cracks of the already formed less acid, and therefore more fusible, rock masses. The presence of a preponderating amount of highly heated water is also claimed by most geologists as a *sine qua non* in the formation of the greisen and pegmatite veins. In many instances the material deposited is white quartz, which undoubtedly represents the final stages of acid segregation; as may be surmised from their mode of origin, these reefs (known to gold miners as "buck-reefs") are practically barren of gold contents, but may well be expected to contain small blebs and

splashes of such "granite" minerals as those found at Stanthorpe —viz., tin, wolfram, molybdenite, &c. Numerous examples of that peculiar variety of crystallised quartz known as "asteriated"—from the star-shaped arrangement of the crystals —were seen, though the occurrence of these did not appear to have any very special connection with the metalliferous deposits.

Whilst admitting the fact that the lode tin deposits were formed at this stage of the differentiation of the fine-grained acid ("Sandy") granite, it should be remembered that dykes and veins of aplitic granite, pegmatites, and greisens were likewise produced as a final result of the cooling of several, if not all, of the other types of still earlier granites to which reference is made in the following chapters. In the case of these latter curitic invasions, however, there does not appear to have been the accompaniment of metalliferous deposits which marks those attending the later acid-granite intrusions.

Throughout the area mapped it was found that the lode tin was in the main confined to the *greisenised* veins and seams. The word "greisenised" is used advisedly, as in many instances it would be quite a misnomer to call the stanniferous rock a greisen, as it is merely an alteration product of the various rock types into a rock that would be more accurately described as a somewhat micaceous quartzose granite. The tin-bearing granites along the Border Range in the neighbourhood of Lode Creek fall under this heading. Typical examples of true greisen, however, occur at Red Rock and the Lord Nolan Mine, both in the Ballandean district. In a majority of the deposits examined it was observed that these greisen veins (particularly those which are true greisens) have a disposition more closely approaching to horizontality than otherwise.

Two very well-marked quartz-felspar-porphyry dykes, about half a mile apart, are situated in the southern portion of the area dealt with, being readily traceable for many miles through the slate country by reason of the prominent bluffs of light-coloured rock which constitute their outcrop. Along the Severn River, in the neighbourhood of the Lord Nolan Mine, these rocks form a very prominent part of the landscape. They are quite parallel and possess a wonderfully constant strike in a north-east direction. The Queen silver-lead-copper lode on the Severn River is located on the wall of the southernmost dyke, to which intrusion it probably directly owes its origin. In the neighbourhood of Sundown the northerly dyke has brought about the deposition of numberless tiny knife-edged siliceous seams through the

enclosing slate rocks, carrying specks of well-crystallised tinstone, though unfortunately the whole rock mass through which the ore occurs has not hitherto been found to be sufficiently high in tin contents to warrant its exploitation as lode-material.

Numerous small dykes of typical quartz-porphyry and quartz-felspar-porphyry traverse the "Stanthorpe" granite along the northern face of a hill near the south-eastern corner of the Rifle Range Reserve. By reason of their relatively greater resistance to denudation the porphyritic crystals of felspar and quartz stand out in bas relief from the groundmass of the intrusion. The felspar crystals are mostly of the orthoclase variety, many being beautifully twinned. Accompanying these dykes are veinlets of opaline quartz and felsite. The strike, where observable, appears to be mainly north and south. The average width of the outcrops shows this formation to be about 8 ft. across, though dykes of a much greater width exist both here and elsewhere (particularly in the Ballandean district). The quartz and felspar crystals assume noticeably smaller proportions as the peripheries of the dykes are approached.

Adjoining the southern side of the Sugarloaf Road (Stanthorpe to Willson's Downfall *viâ* Sugarloaf) in portion 71, parish of Folkestone, a typical outcrop of a faulted graphic granite vein can be clearly seen intruding the coarse-grained acid ("Stanthorpe") granite. The vein of graphic granite—which passes into aplite at times—is here seen traversing the older rock in a roughly east-north-east direction, whilst the fault planes have bearings ranging from north-east to north. The close proximity of the main mass of fine-grained acid ("Sandy") granite points to a very probable connection between this latter rock and the vein. Whilst there can be no doubt but that the occurrence represents one and the same vein it is impossible to observe any definite faulting in the enclosing rock mass, and hence it is quite possible that the material of which the graphic granite is composed has been injected into cooling cracks set up in a not completely solidified granite magma. The fault planes are occupied by knife-edged veins of brittle white and bluish quartz.

The accompanying sketch plan (Figure No. 1) of this occurrence will illustrate the phenomenon, which is very typical of countless other quasi-faulted intrusions belonging to the curitic phase. However, it is highly probable that the existence of such intrusions, especially in the older series of granite at distances removed from the large later "Sandy" granite outcrops, is referable to acid segregations from the former granite

magmas themselves which have been injected into the cleavage cracks set up by cooling at that time.

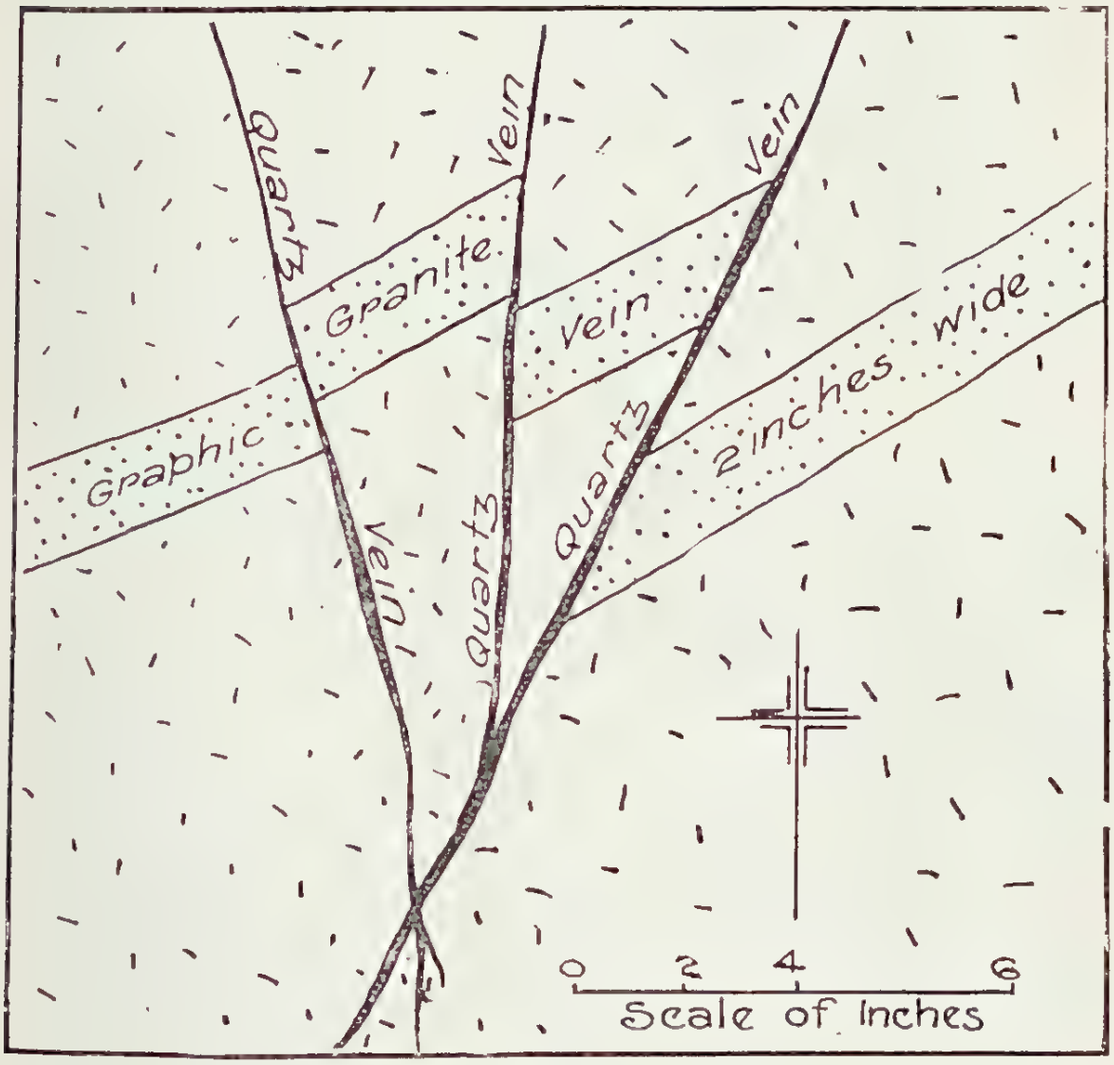


Fig. 1.

A characteristic structure seen in the acid veins intruding the granites ; Sugarloaf Road.

Close to the north-east corner of Mineral Lease 126, Red Rock Creek, at the junction of the "Sandy" granite and the overlying intruded slates, occurs a remarkably interesting pegmatite seam. This formation is on the actual junction of the two rock masses named, and is immediately succeeded by a fine-grained aplite in which are set numberless prominent crystals of orthoclase showing mostly basal sections; longitudinal sections are also present, as also are both basal and longitudinal sections of quartz. The felspar sections average one inch across, whilst sections of quartz attaining a length of 6 in. are common. A few dark-coloured segregations (tourmaline mainly) are scattered through the pegmatite. Some 10 ft. in width of this highly porphyritic aplite is exposed in the creek bed, but a still greater width might be exposed by the removal of material along the

left bank of the stream. The truly pegmatitic portion of the occurrence averages some 10 in. in width, but passes insensibly into the aplitic portion, the quartz crystals of the former frequently passing out into the latter. At times the quartz and felspar crystals show intergrowth even in the aplitic portion of the formation. On the left bank of the creek the pegmatite is apparently lying horizontally on the surface of the porphyritic aplite, as also does an accompanying small greisen vein. Both muscovite and biotite are present in the pegmatite, frequently in very close proximity to each other. The porphyritic crystals of quartz and felspar are somewhat irregular as regards their distribution through the aplitic rock, portions of the latter being devoid of crystals whilst in others again they are crowded together, such crowding increasing rapidly and finally culminating in the assumption of a characteristic coarse-grained pegmatite vein. The tourmaline was observed to be limited to the truly pegmatitic zone of the occurrence.

FIG. 2

Pegmatite and aplite veins at the junction of the "Sandy" granite and slates; Red Rock Creek.

Fine-grained Acid Granite (the "Sandy" Granite).

This rock, which is of scarcely less importance from the standpoint of ore genesis than the closely related acid dykes and veins just described, belongs, as do they also, to the euritic phase of differentiation of the main New England granite magmas.

As it has been recognised for some years that most of the tin, wolfram, molybdenite, and bismuth deposits of this portion of Australia owe their existence directly to the presence of this important rock series, particular attention was paid to this formation during the present survey.

When mapping the New South Wales side of the border a few years ago I found that the two most important outcrops in the area then examined passed over into Queensland. As no opportunity for studying the shape of these intrusions as a whole then presented itself, their relationships to other granites and also their disposition was of necessity much a matter of speculation. The work now carried out by me in the Stanthorpe area enables a better grasp of their structure and connection with the tin deposits to be obtained. Seeing that much discussion has from time to time centred around the rocks of this class, it was thought desirable to map their outcrops as accurately as this granite-soil-covered area would permit; in many instances the actual boundary itself was visible, in which case I have attempted to show the ramifications innumerable that characterise it.

By reason of its usually greater acidity and consequently greater resistance to the various agencies producing rock decay than the granites it intrudes, this rock frequently forms hard hill ridges and isolated peaks; in the case of the two main outcrops seen it actually forms portions of the main dividing range between the States. To the west of the Broadwater, in parish of Marsh, it forms particularly rugged mountains.

The disintegration of this rock results in the liberation of great quantities of angular quartz sand, hence the name "Sandy" which has been applied to it. In the central portions of the intrusions this sand is a most marked feature, as witness the heavy pulling for horses on the sandy road between the border and Amosfield, on the Ruby Creek road from Stanthorpe. As may be expected from its chemical composition, *vide infra*, it supports mostly a very poor and stunted vegetation consisting largely of stunted gums, dog-wood (*Jacksonia scoparia*), honeysuckle (*Banksia*), *Casuarina*, *Epacridæ*, &c., as also grass of a

very poor quality. Speaking generally it may be said to be worthless from the agriculturist's point of view, though in depressions where an accumulation of soil representing the waste of this rock is met with, fruit trees are often found to thrive; however, as will be pointed out later, this result is achieved rather by reason of the ability of trees to establish extensive root systems in loose material than to any inherent soil-fertility. Most of the areas known to cause the disease called "rickets" in cattle are land of poor quality resulting from the "Sandy" granite.

The junction between the "Sandy" granite and the coarse-grained acid granite ("Stanthorpe" granite) which it intrudes is often clearly marked; particularly clear lines of invasion can be seen along Herding Yard Creek and Sugarloaf Creek.*

An outstanding feature of the invasion of the coarse granite by this finer (and usually more acid) variety is the marked improvement effected in the former by the latter as regards resistance to weathering. A splendid example of this fortification of a pre-existing granite is afforded in the instance of the well-known hill, known as Mount Marlay, in the township of Stanthorpe; a glance at the accompanying geological map will show the close proximity of the "Sandy" granite to this outcrop of "Stanthorpe" granite. In several positions on the hill are seen dykes of aplitic granite radiating out from the "Sandy" granite. In my opinion, the shape of several similar "Stanthorpe" granite hills around this district points to the probability of their internal cores being composed of the last-named rock; examples to illustrate this theory are to be seen in the cases of the rocky area known as Donnelly's Castle, the ridge behind Mount Banca, Mount Magnus, &c.

The country produced by this invasion of the fine-grained into the coarse-grained acid granite is perhaps the poorest in the whole of this region as regards agricultural and grazing possibilities.

Although, as stated above, the effects produced in the invaded rock mass are well marked as a whole, the actual contact point itself where visible is usually well defined; in fact, this bounding line is often even accentuated by the existence of a marginal zone to the fine-grained rock in the form of extremely fine-grained felsitic material which approaches to the structure of a rhyolite at times. Perhaps the best instance of this characteristic can be seen along Herding Yard Creek, Amosfield

* *Vide* Plate VII. in Mineral Resources of N.S.W., p. 86

(N.S.W.), where the rock assumes a markedly glazed appearance by reason of the extremely high silica content of the portion constituting its actual physical border.

Numerous "pipe"-like structures, consisting of apparently circular pegmatites of highly acid composition, characterise the marginal zone of this rock mass. At times the peripheral area is traversed by a multitude of still-finer grained aplite veins, some of which are of extreme tenuity, those possessing a horizontal disposition resembling a shawl or lace-like substance rather than the hard resistant rock they actually are.

Quartz veins representing the final stages of segregation traverse these rock masses, particularly along the marginal zones, where they have a disposition rudely parallel to that of the boundary between the invading and invaded rock masses. The photograph of a hand-specimen (Figure 9) illustrates—(*a*) the well-defined line of demarcation between the boundary edges of the "Stanthorpe" and "Sandy" granite, and (*b*) incipient quartz veins traversing the "Sandy" granite.

The actual peak of Sugarloaf Mountain is composed of this rock, though by far the greater portion of the Sugarloaf Mountain ridge consists of the "Stanthorpe" variety.

The lode-tin area in the Red Rock district is located in an outcrop of this rock intruding slates.

In the Ballandean district numerous outcrops occur, notably along the track to the Lord Nolan leases.

Numerous extensive complicated outcrops of this rock are to be seen along the rabbit-proof fence, parishes of Marsh and Rosenthal, but the limited time at my disposal did not permit of their boundaries being fixed with more than an approximation to accuracy.

Judging from the number and extent of the intrusions of this rock seen crossing the border between Wallangarra and Bald Rock, it must have a great development in the portion of New South Wales adjoining that line. A prominent outcrop is seen intruding the porphyritic granite almost within the town of Wallangarra (see Map No. 3).

A large prominent dyke-like outcrop of aplitic granite (Figure No. 2) can be clearly seen in the bed of the stream, crossing Quart Pot Creek some 4 chains downstream from the railway bridge, not far from Stanthorpe Railway Station. The strike (at the creek bed) appears to be north and south, taking the formation generally, but reference to the accompanying figure

will show that the intrusion has an octopus-shaped outcrop. As this intrusion is typical of many others throughout both Stanthorpe and New England, it was deemed important to map it in on a large scale with as much accuracy as possible in order to learn something of their origin and mode of invasion. The particular occurrence herein mentioned is extremely fine-grained and affords an excellent example of the felsitic grain structure induced in an otherwise granitic rock by the injection of highly heated molten magma into a cold rock-mass. In common with its enclosing coarse-grained acid ("Stanthorpe") granite this later acid intrusion is traversed by master joints, one set having a bearing here of 70 degrees, crossed by a second set (the principal) coinciding with the apparent general strike of the intrusion itself. This fact indicates that the jointing has been developed in the rock masses at a period subsequent to the intrusion of the aplitic granite into the normal granite. The aplitic granite becomes gradually coarser-grained towards the central mass of the outcrop. In addition to the two sets of master joints just enumerated, the rock is here further subdivided by a series of horizontal "floors" having a dip in a north-westerly direction at a low angle (5 degrees approximately). When traced in a southerly direction the outcrop takes a curve to the eastwards across the railway line, where it can be well seen in the rock cutting near the southern end of the bridge; at this last named spot it is several chains in width. On the upstream edge of the dyke may be seen wedge-shaped tongues of increasingly siliceous felsitic rock frequently culminating in quartz veins which are traceable for some distance easterly. Sills of aplitic granite are also visible hereabouts, their connection with the main central "knot" being readily discernible.

As in the case of the dykes and veinlets, the extreme edge of these invading sills is almost microscopically crystalline, due to its rapid cooling when intruded into cold rocks. The philosophy of these observations is that the later fine-grained acid granites and their still more recently formed greisen, &c., veins must have been introduced into the pre-existing rocks at no very great depth below the then surface, and therefore at a time when denudation following on uplift had removed a great thickness of overlying rock. Continuing this line of argument it makes it possible for the newer rocks to be provisionally assigned to a Late Mesozoic Age, seeing that the rocks to be described subsequently—namely, the Biotite Granite and the Porphyritic Granite (sphene-bearing)—are considered to have been intruded in Early Mesozoic times.

Odd veinlets of quartz traverse the dyke itself, representing residual silica deposited along fracture cracks set up during the stage which witnessed the cooling of the molten magma. These veinlets exhibit frequently a length altogether out of proportion to their linear extent, knife-edged veins of quartz being traceable for many chains in length.

On the right bank of the creek the outcrop becomes split up into short branches ending very abruptly, though of course a continuation of the intruding aplite would be found through the coarse granite at a depth. After a fairly varied experience of dyke rocks I am convinced that a feature often lost sight of in geological mapping is that intrusive igneous dykes, whether of acid or basic composition, very frequently have but a relatively short *surface* outcrop, due to the fact that the upper original surfaces of the intrusions are often most irregular in contour; hence a dyke that actually outcrops at the present ground surface at one spot may not approach the surface at any other spot albeit it may be wonderfully persistent as regards length. Again —and probably herein lies the true explanation of the frequent absence of any apparent continuation of dyke rocks—the dykes themselves have often no such great individual linear extent as that suggested by older geological maps showing narrow intrusions many miles in length, but have in reality a disposition comparable to the series of parallel cracks set up in a pine-board after being left out in the weather for some time. Each dyke takes its rise from a point close to the termination of another similar occurrence and maintains a rudely lense-shaped (narrow) outcrop, gradually tapering out to a point, when still other parallel dykes will take their rise at usually short distances to the left or right of the preceding intrusive rock.

Good examples showing the transition from aplitic dykes to quartz-porphyry may be seen in Quart Pot Creek, portions 54 and 86, parish of Folkestone.

Thin pegmatite veins accompany the intrusion at several points along its southern extension. Along its northern edge the aplitic granite is accompanied by several reefs of bluish-white partly crystallised highly brittle quartz from which lode tin in negligible quantity was obtained some years ago. Complete evidence is here furnished by the pegmatites to indicate that the reefs abovementioned constitute the product of the ultra-acid phase of differentiation in the presence of much heated water. A fair proportion of the quartz exhibits the characteristic pale amethyst tinge commonly seen in stanniferous quartz veins. Huge crystals of orthoclase, intergrown with large quartz crystals,

abound and exhibit a marked yellow colour, due to the formation of hydrated oxide of iron from the various iron-mineral associates (*e.g.*, ilmenite, magnetite, &c.) present in the felspars.

Upstream from the railway bridge, and apparently connected at its northern end with the main aplitic granite mass under review, occurs a well-defined dyke averaging 14 in. wide, which width it maintains constantly for several chains across the hard bare floor of "Stanthorpe" granite. The general strike of this small dyke is 285 degrees, though numerous minor local deflections from that course are clearly visible; these semi-breaks in the continuity of the outcrop are not due to any subsequent shattering (*e.g.*, fault) movements bringing about displacement, but are indicative of the irregularity in the course of the early cleavage cracks set up in the coarse-granite immediately prior to the injection of the dyke magma.

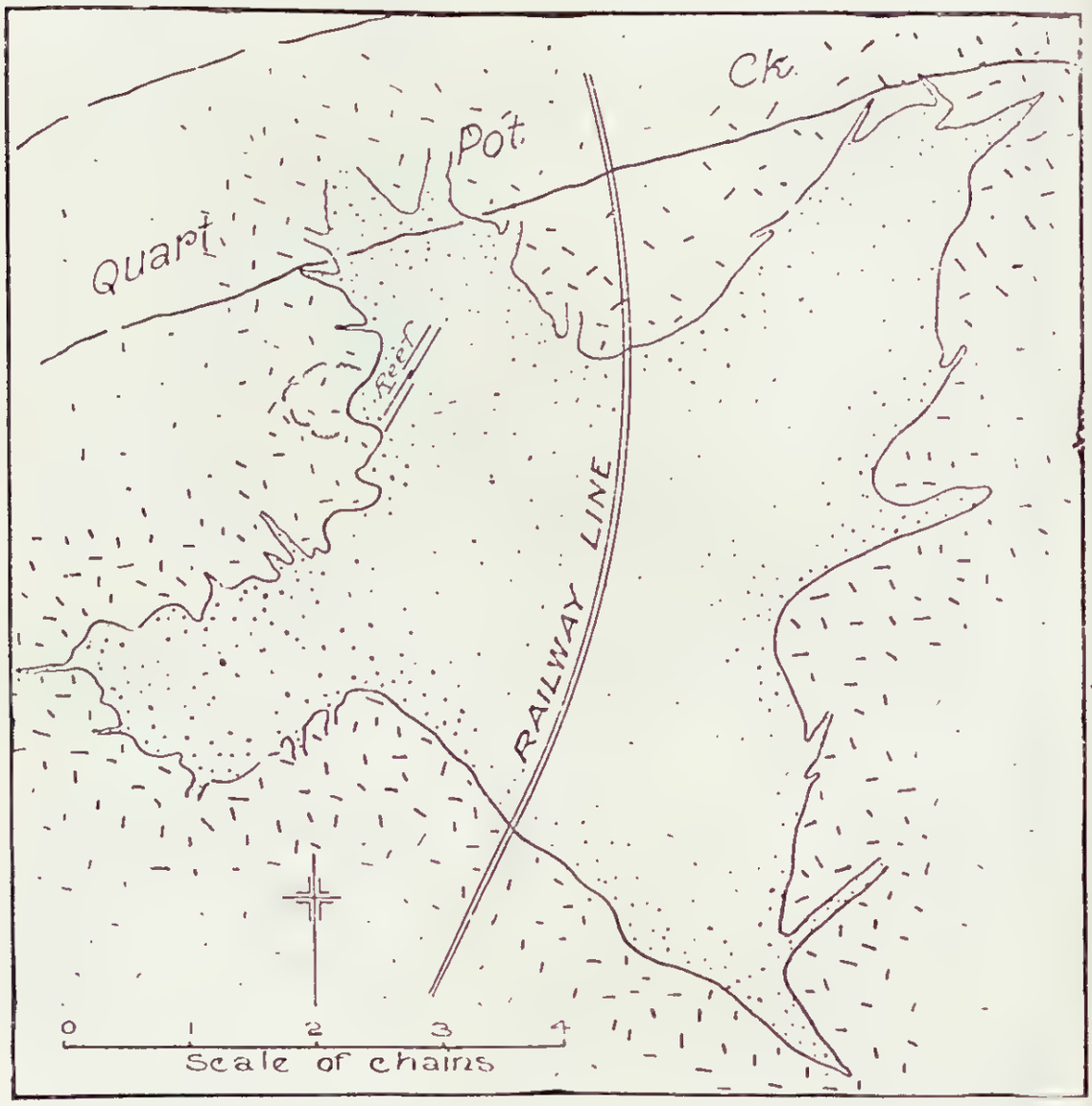


Fig. 3.

Typical octopus-shaped outcrop of the "Sandy" granite intruding the "Stanthorpe" granite; Quart Pot Creek, Stanthorpe.

A carefully averaged sample, obtained by collecting a large number of typical samples of this "Sandy" granite from the outcrops seen in the parish of Ruby, county Buller (on the New South Wales side of the border) was submitted by the writer for petrological and chemical investigation in 1910. Mr. Card, Petrologist to the New South Wales Geological Survey, describes the rock as being*

> "A pinkish gray granite weathering red, grain-size medium. Sub-porphyritic, with comparatively large crystals of white orthoclase. Biotite occurs sparsely disseminated as small flakes, and in inconspicuous nests."

The chemical analysis of this sample, conducted in the Geological Survey Laboratory (N.S.W.) by Mr. W. A. Greig, Assistant Analyst, shows that its composition in the area named is as appended:—

	Percentage Composition.	Molecular Ratio.
Silica	76·52	1·275
Alumina	12·73	125
Ferric oxide	0·48	3
Ferrous oxide	0·62	8
Magnesia	0·14	3
Lime	0·75	13
Soda	3·58	58
Potash	4·59	49
Water (100°C)	0·17	..
Water (100°C)†	0·37	..
Carbon dioxide	0·04	..
Titanium dioxide	0·07	..
Zirconium dioxide	absent	..
Phosphoric anhydride	0·02	..
Sulphur trioxide	absent	..
Chlorine	†trace	..
Fluorine	absent	..
Chromium sesquioxide	absent	..
Nickel and Cobalt oxides	absent	..
Manganous oxide	0·12	..
Baryta	absent	..
Strontia	‡present	..
Lithia	‡present	..
Vanadium sesquioxide	absent	..
Copper oxide	†trace	..
	100·20	

* Mineral Resources of New South Wales, No. 14, p. 85.

† Less than 0·01 per cent.

‡ Spectroscopic reaction only.

Calculating from the above figures we obtain the following norm:—

Quartz	36·42
Orthoclase	27·24
Albite	30·39
Anorthite	3·61
Corundum	0·51
Hypersthene	0·96
Magnetite	0·70

A second sample (from portion 3, parish Ruby, county Buller) submitted to Mr. Card was referred to by that gentleman in the following terms:—

> "A pink, rather fine-grained rock, showing a very little biotite, in addition to quartz and felspar. Under the microscope, a good proportion of oligoclase is seen. Some of the felspar shows micro-perthitic structure, and may be microcline."

A sample of granite from the Stanthorpe area (identified by the writer as being of the "Sandy" variety) was analysed in the Queensland Agricultural Department's Chemical Laboratory, by Mr. G. R. Patten, Assistant Chemist. By the courtesy of Mr. J. C. Brünnich, Agricultural Chemist, I am enabled to publish the results of this examination, as appended:—

	Percentage Composition.
Silica	77·15
Alumina	11·53
Ferric oxide	0·84
Ferrous oxide	1·25
Magnesia	0·60
Lime	1·14
Soda	3·80
Potash	4·14
Water —	Nil
Water +	0·28
Titanic oxide	0·09
Phosphoric acid	0·25
Manganous oxide	0·16
	100·27

Norm, calculated from the above analysis, gives:—

Quartz	44·22
Orthoclase	19·46
Albite	23·06
Anorthite	5·28
Corundum	3·47
Hypersthene	4·31
Magnetite	0·70
Apatite	0·34
Water	0·28
	101·12

Magmatic name—**Toscanose.**

A comparison between the above figures shows the composition of this intrusive mass to remain fairly constant throughout the petrographical province. The care taken in the actual collection of a typical average sample over many square miles of country, however, warrants the first of the two above-mentioned analyses being considered to be the more representative one.

It is of interest to record the fact that the tinstone occurring in the area occupied by this particular variety of acid granite is characterised by—

(*a*) Absence of black sand;

(*b*) High purity (as regards metallic tin contents);

(*c*) Ruby colour.

This is in marked contrast to the abundance of black sand, *e.g.*, at Wylie Creek, and the generally black colour of the tinstone obtained from those streams draining coarse-granite outcrops.

The Coarse-grained Acid Granite (the "Stanthorpe" Granite).

A glance at either the sketch plan showing the whole petrographical province dealt with or the Stanthorpe area itself, will suffice to show that by far the greater portion of the region geologically mapped is occupied by outcrops of a coarse acid granite. In view of the fact that this rock finds perhaps its greatest development in the Stanthorpe area, and also that that town is the only large centre of population contained within this rock province, it has been decided to assign the name "Stanthorpe" to it throughout the present report. Being a characteristic rock in the Stanthorpe township area, the name now applied to it is one that will be readily understood locally.

As is only to be expected from its great regional extent, this rock mass exhibits a remarkably varied set of facies in the different localities where it is seen, in fact no petrologist who had seen only hand-specimens would consider the different types to be merely local variations of the one great intrusion. Taking the case of the well-known Sugarloaf Range on the border, the rock is here decidedly acidic in character, but becomes gradually but decidedly more basic in chemical composition as it is traced in a northerly direction. This variation in chemical composition is illustrated by the widely different analyses yielded by various samples throughout its area (*vide* analyses below).

This rock produces soils of every colour from light yellow to red, according as it is acidic or basic in composition.

Several veins of greisen occur through this rock—especially at the head of Herding Yard Creek and its tributaries along the border, Lode Creek, &c. These veins usually carry small quantities of tin and wolfram, with occasionally insignificant quantities of molybdenite; coatings of iron and copper pyrites along joint-cracks are abundant through these mineralised greisen veins.

Owing to its relatively weaker resistance to the agencies of sub-aerial denudation, this rock, except in the cases where it has been reinforced by dykes and siliceous solutions from the later intruding "Sandy" granite as mentioned previously, has largely been worn down to swelling country traversed by broad open stream channels. Its chemical composition being frequently more nearly that of a rock containing sufficient plant food to provide a soil rich enough to support timber trees, than that of the "Sandy" granite, the existence of this rock below its covering regolith can usually be easily deduced from the presence of well-grown gums and stringy-bark. The line of demarcation through timbered country between these two rock-types is often quite marked when once it has been recognised, particularly in the Willson's Downfall portion of the area mapped, the coarser rock being indicated by the best grown timber, whilst the *Banksia* and stunted gums, &c., mostly point to the presence of the finer-grained type.

Speaking generally, the "Stanthorpe" granite is characterised by a markedly pink colour due to the abundance of pink orthoclase felspar which is seen through the rock. This coloration does not, however, persist over the whole region examined, for at Willson's Downfall the rock has a preponderance of long white felspars having a marked orientation. So pronounced is the difference between these two varied types of the same rock-mass that Mr. Andrews holds the view that they are members of two distinct intrusives, but the writer, having an intimate knowledge of this rock over the whole of the area now dealt with, has no doubt whatever but that they represent merely variations due to local segregations in the original molten mass. All along the western margin of this rock, adjoining the line of junction between it and the intruded slates, *e.g.*, near Ballandean Station Homestead, the partial absorption of the slates and the more rapid cooling of the invading rock, have tended to produce a finer-grained rock with much lighter-coloured

felspars than that seen elsewhere. A similar production of white felspars is seen in the northern portions of the area mapped near the slate-granite junction in the neighbourhood of Mount Magnus and towards the head waters of Pike's Creek.

A somewhat more acid type of this rock than the normal form is that seen on portions 82 and 70, parish Stanthorpe; in this case it is at times a matter of considerable difficulty to definitely distinguish it from the "Sandy" granite. Numerous small aplitic granite dykes traverse the mass hereabouts.

Mount Banca, a very prominent hill (3,052 ft.) close to Stanthorpe township, is composed of a rather acidic type of the coarse acid granite which is here traversed by occasional aplitic veins and small pegmatites. A close resemblance is noticeable in the rock itself to that seen at Mount Marlay, the preservation of these two elevated areas being directly referable to the more quartzose character of the rock as compared with the normal granite.

To the north of Mount Banca is a very prominent face of smooth rock of similar composition to that just described; this cliff, which is known in Stanthorpe township as Bald Rock No. 2, exhibits the characteristic north-east and south-west trend induced by the master joints through the granite.

Mount Magnus is composed of "Stanthorpe" granite through which several acid dykes have been intruded, one being through the actual summit at the trigonometrical cairn; width of dyke about 6 in.; strike N 60 E, dip slightly west. On Mr. Browne's property in this district the granite is rather finer-grained, due doubtlessly to the proximity of the intruded slates. Odd patches of slate, indeed, still remain as islands in the granite, indicating that the present upper surface of the granite in the immediate neighbourhood closely approximates to the original one produced at the time it was intruded into the sedimentary strata. Owing to the amount of slatey rocks which must have been digested by the granitic magma along its margin, the soil produced by its decay is productive of better grazing land than that from the normal granite.

A very coarse porphyritic type of this rock, obtained by the writer from an outcrop at Amosfield, near the Maryland road turn-off from the Stanthorpe road, showing phenocrysts of cream-coloured orthoclase and a moderate quantity of small crystals

of biotite, was analysed in the Geological Survey Laboratory (N.S.W.), in 1910, by Mr. H. P. White, Assistant Analyst, who records the accompanying chemical analysis:—

	Percentage Composition.	Molecular Ratio.
Silica	67·24	1·121
Alumina	14·20	139
Ferric oxide	1·50	9
Ferrous oxide	2·88	40
Magnesia	1·39	35
Lime	3·24	57
Soda	3·98	65
Potash	4·07	43
Water (100°C)	0·12	..
Water (100°C+)	0·50	..
Carbon dioxide	0·06	..
Titanium dioxide	0·65	8
Zirconium dioxide	absent	..
Phosphoric anhydride	0·11	1
Sulphur trioxide	absent	..
Chlorine	*trace	..
Fluorine	absent	..
Chromium sesquioxide	absent	..
Nickel and cobalt oxides	absent	..
Manganous oxide	0·06	..
Baryta	0·07	..
Strontia	†present	..
Lithia	†present	..
Vanadium sesquioxide	absent	..
Sulphur (ferric sulphide)	absent	..
	100·07	

Specific gravity, 2·7111. No gold or silver present.

Calculating from the above figures, Mr. Card obtains the following norm:—

Quartz	19·41
Orthoclase	23·91
Albite	34·06
Anorthite	8·62
Diopside	3·03
Hypersthene	7·12
Magnetite	1·86
Ilmenite	0·15
Apatite	0·34

Regarding a further sample of the coarse granite from Willson's Downfall, Mr. Card states:—

> "Under the microscope the felspar is seen to include so much oligoclase as to bring the granite into the *Adamellite* division of some authors. In addition to biotite and hornblende, sphene, zircon, and apatite are present as accessories. The rock is quite fresh."

As compared with the Willson's Downfall variety, which appears to possess somewhat dioritic affinities, the appended

* Less than 0·01 per cent.
† Spectroscopic reaction only.

analysis of typical samples of fresh rock from (1) a quarry at Stanthorpe and (2) a medium-grained variety from Ballandean, recently analysed by Mr. G. Patten, Assistant Chemist in the Queensland Agricultural Chemistry Laboratory, shows the normal rock to be sufficiently high in silica to warrant its designation as an acid granite:—

	Percentage Composition.	
	(1)	(2)
Silica	76·19	74·89
Alumina	11·53	15·11
Ferric oxide	0·84	1·06
Ferrous oxide	1·25	2·26
Magnesia	0·60	0·82
Lime	1·14	1·67
Soda	3·80	2·06
Potash	4·14	0·73
Water—	Nil	0·31
Water+	0·28	0·50
Titanic oxide	0·09	..
Phosphoric acid	0·25	0·27
Manganous oxide	0·16	0·22
	100·27	99·90

According to the above quoted figures, the norms work out as under:—

Quartz	35·16	54·42
Orthoclase	24·46	4·45
Albite	31·96	17·29
Anorthite	3·89	6·67
Corundum	..	8·47
Hypersthene	2·95	5·56
Magnetite	1·16	1·62
Ilmenite	0·15	..
Apatite	0·62	0·67
Water	0·28	0·08
	100·35	99·96

The Magmatic name of No. 1 would be **Liparose.**

As stated previously, in the chapter dealing with the physiography of the district, the development of rounded blocks and "tors" is rather a characteristic feature of the outcrop of this coarser-grained intrusion. The soil formed from it is also fairly easily distinguishable from that of the "Sandy" granite in that it is mostly composed of an admixture of coarser-grained quartz sand and recognisable fragments of pink orthoclase; this composite soil waste at times assumes quite a mottled appearance. The soil resulting from the decay of this formation is also differentiated frequently by the presence of a greater amount of kaolin and coloured clay amongst the sand grains than is to be found on the later intrusive granites.

The accompanying photograph of a well-known spot, known as the Sentimental Rocks, close to the town, adjoining the road

to Ballandean, illustrates the common shape assumed by ordinary blocks of this rock when subjected for some time to weathering. The steep flat sides to the individual blocks of rock are due to master joints. A good view of the township and also of the railway line in the direction of Wallangarra is obtainable from

[*Photo: L. Jobson.*

PLATE 2.—SENTIMENTAL ROCKS, STANTHORPE.

A typical outcrop of the "Stanthorpe" granite

this group of rocks. I understand that the gentleman on whose property these picturesque formations occur has quite lately generously donated the area to the public.

These rocks afford a good illustration of the characteristic rounded shape assumed by blocks of "Stanthorpe" granite when subjected for some time to weathering agencies.

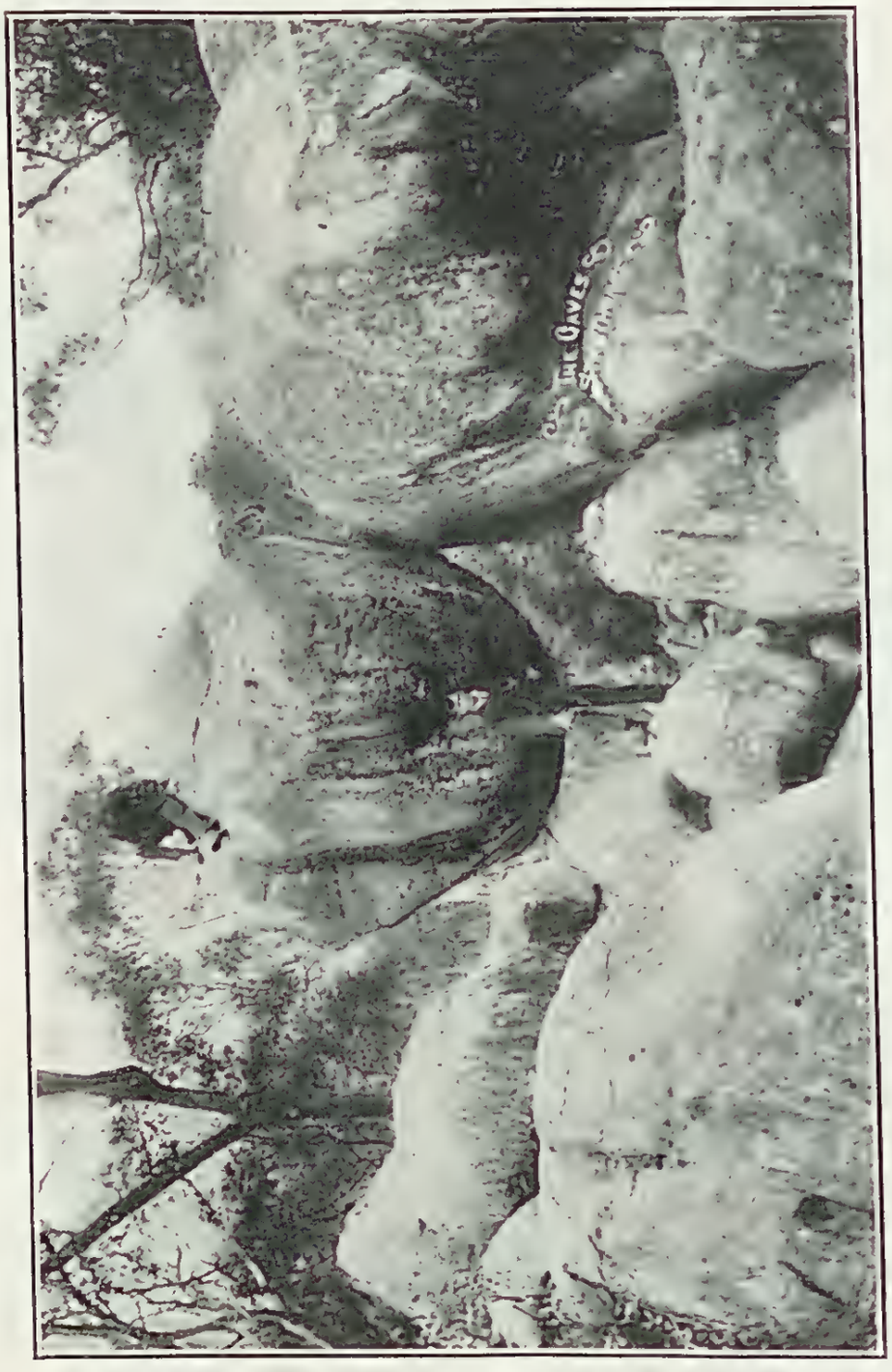
Some of the results produced by weathering on exposed blocks of this stone are evidenced in the photograph (Plate 3), which shows a large rudely oval-shaped mass of granite resting on a base smaller than must formerly have been the case. This represents a future "tor" in the making. The grooved weathered surface of the block is a feature common to this formation everywhere, an excellent example being that afforded by the immense bare rock mass known as the Pyramids, situated close to Bald Rock in the Wallangarra district.

PLATE 3.—A BOULDER OF "STANTHORPE" GRANITE.

Showing the characteristic weathering of rock having the typical mineral composition.

In the case of the rocks seen at the entrance to "The Caves" (Plate 4) the process of tor-production has reached a stage further than that seen in the preceding photograph. The large rounded boulder in the centre of the picture has now but a very limited base on which to rest. These "Caves," so-called, are merely cavities formed by the leaning together of loose blocks of granite on the side of a ridge. In the case of the main "cave" there is a space of a couple of feet in width by some 20 ft. in depth between two well-defined granite walls which owe their origin to master-joints. These spaces between the large boulders are nearly all connected to the surface, as is to be expected. At the end of the short passage from the bottom of the principal "cave" (of which the accompanying photograph shows the entrance) is the remains of a very old fire, which local

tradition ascribes to a hiding place of the notorious bushranger "Thunderbolt." For this reason this group of interspaces between loose granite blocks is generally known in the Stanthorpe district under the name of Thunderbolt's Cave.



[*Photo: L. Jobson.* PLATE 4.—ENTRANCE TO "THE CAVES," STANTHORPE.
Showing a typical bouldery outcrop of the "Stanthorpe" granite.

The effect of weathering agencies upon a rock mass already exhibiting lines of structural weakness in the form of master-joints is to still further accentuate these cleavages by a gradual process of rock decay, ultimately resulting in the production of isolated boulders. The photograph (Plate 5) of the prominent rocks near the town, known locally under the descriptive name of the "Divided Rock," is a good illustration of this operation,

the weathering in the present instance not having been carried on to a point sufficiently far to mask the determining factor—viz., the sets of pre-existing master-joints by which the granite is divided.

PLATE 5.—"DIVIDED ROCK," STANTHORPE. [*Photo., L. Jobson.*

A characteristic effect produced by the weathering of the "Stanthorpe" granite along master-joints.

The very typical rock outcrop seen in the picture on Plate 6 illustrates the production of:—(*a*) The rounded bouldery outcrops, and (*b*) a "tor," composed of "Stanthorpe" granite of the normal chemical composition. The view shown is that of a well-known group of rocks close to the township.

PLATE 6.—BALANCED ROCK, STANTHORPE. [*Photo., L. Jobson.*

A common feature produced by the weathering of the "Stanthorpe" granite

The fortification of the "Stanthorpe" granite by (1) the gridironing of this rock mass by acid dykes in areas not far removed from large outcrops of the "sandy" granite, and (2) the addition of secondary silica derived from the magma of the latter intrusion, is illustrated to a certain extent by the

photograph (Plate 7), which gives a view of the summit of Mount Marlay. The prominent rock outcrop in the picture is that of portion of this "Stanthorpe" granite hill, which has been strengthened and rendered more acidic in composition by the agencies enumerated.

PLATE 7.—SUMMIT OF MOUNT MARLAY, STANTHORPE. [*Photo., L. Jobson.*

Showing a prominent outcrop of "Stanthorpe" granite which has been hardened by the intrusion of a neighbouring boss of acid ("Sandy") granite.

A similar result is evidenced in the case of Winstead Falls, a view of which is given in Plate 8.

PLATE 8.—WINSTEAD FALLS, STANTHORPE. *Photo., L. Jobson.*

The granite has been hardened by the intrusion of acid granite dykes.

Plate 9, which is a photograph of a hand specimen (about half the natural size) shows the remarkably sharp line of demarcation frequently observable between the coarse and fine grained acid granite masses along the line of intrusion. Note the incipient quartz veins in the "sandy" granite (*vide* previous chapter).

PLATE 9.—HAND SPECIMEN. [*Photo., R. Graff.*

Showing the well-defined line of contact between the "Stanthorpe" (coarse) and "Sandy" (fine-grained) granites.

The Porphyritic Granite (Sphene-bearing).

Crossing the border from the Tenterfield side into Queensland, in the immediate vicinity of, and including, the township of Wallangarra, is a large intrusive mass of a grey granite which is characterised by—

(*a*) Magnificent large porphyritic crystals of orthoclase felspar;

(*b*) Fairly abundant macroscopic sphene showing the typical wedge-shaped crystals, and

(*c*) A remarkable wealth of large basic segregations.

This rock-mass is productive of a fairly good soil containing much clay; it supports excellent grass and good timber and its outcrop, being more readily decomposed than the adjoining later acid granites, has been worn down to form rolling park-like lands, the hills of the latter granites standing out sharply along its eastern and north-eastern edges.

On the Queensland side, in the Wallangarra area, this rock has a comparatively limited extent (see Map No. 3), but the intrusion can be seen in great force at several places in the petrographical province here dealt with, particularly along the Herding Yard Creek below Amosfield (see Map 2) and Undercliffe. Mr. Andrews* records its occurrence at several places scattered over a wide area, in New England, notably at Malarra, Bolivia, the Drake-Tenterfield road, Moonbi, Walcha Road, &c. A small isolated intrusion was noted by the writer in portion 81, parish of Tenterfield, in that rugged area lying between Mount Norman and Bald Rock ridge.

The presence of such markedly porphyritic crystals set in a rather dark background makes this rock pre-eminently suitable for decorative columns to buildings, and it is surprising that the undoubtedly great beauty of this stone has not apparently yet been turned to account for the purpose indicated.

Mr. Andrews, who has an intimate knowledge of this rock throughout northern New England, states that the characteristic trees found growing on the porphyritic granite are *Eucalyptus viminalis, E. conica, E. tereticornis,* and *Angophora subvelutina.*

Five typical samples were selected by Mr. Andrews and submitted to Mr. Card, Petrologist to the New South Wales Geological Survey, who furnished the accompanying petrological description:—*

> "*Sample No. 1, from the 6½-mile peg on the Wilson's Downfall-Rivertree Road.*—A distinctly porphyritic variety, with tabular phenocysts of flesh-coloured orthoclase, which may show Carlsbad twinning well. The general ground-mass shows biotite, hornblende, and glassy white felspar; sphene is readily detected. It is often almost black with ferro-magnesian silicates.

* Records of the Geological Survey of New South Wales, Vol. VIII., Part 3.

"Under the microscope the dominant felspar of the ground-mass is seen to be a variety of oligoclase. The felspar shows composition zoning. The twin lamellæ are sometimes only locally developed in an individual crystal, and their development is to some extent connected with a change in the angle of extinction; it is, therefore, concluded that in such cases the twinning is secondary, and an effect of strain. Biotite, apatite, and magnetite may be seen enclosed in the felspar. Hornblende is sometimes intimately associated with biotite; it is well-cleaved, and shows pleochroism in shades of brown and green. Apatite and magnetite are present, and the slide contains no less than eight distinct fragments of sphene."

Separate analyses were made of the general ground-mass, and of the porphyritic crystals of orthoclase. The results of these analyses, conducted in the Chemical Laboratory of the Department of Mines, Sydney, are appended. Analysis A (Willson's Downfall Porphyritic Granite, excluding the orthoclase phenocrysts) was made by Mr. J. C. H. Mingaye, and B (the orthoclase crystals themselves) by Mr. H. P. White:—

	A.		B.
	Weight Percentage.	Molecular Ratio.	Weight Percentage.
Silica	64·20	1·070	65·60
Alumina	16·94	·166	17·82
Ferric oxide	2·00	·012	0·10
Ferrous oxide	2·44	·034	0·27
Magnesia	2·03	·051	0·17
Lime	4·56	·081	0·32
Soda	4·00	·064	3·84
Potash	2·76	·029	11·34
Water (100°C)	0·14	..	0·23
Water (100°C+)	0·47	..	0·25
Carbon dioxide	0·01	..	..
Titanium dioxide	0·39	·005	Nil
Zirconium dioxide	none	..	..
Phosphoric anhydride	0·22	·001	0·02
Sulphur trioxide	0·12	..	..
Chlorine	trace	..	trace
Sulphur (ferric sulphide)	trace	..	..
Chromium oxide	trace	..	..
Nickel and Cobalt oxides	0·01	..	..
Copper oxide	0·01	..	..
Manganous oxide	0·07	·001	trace
Barium oxide	0·02	..	absent
Strontium oxide	trace	..	absent
Lithia	none	..	present
Vanadic oxide	none	..	..
	100·39	..	99·96
Specific gravity	2·705	..	2·552

Calculating from the above figures (Sample A) Mr. Card arrived at the following norm for the general ground-mass of the rock:—

Quartz	17·40
Orthoclase	16·12
Albite	33·54
Anorthite	20·29
Diopside	1·14
Hypersthene	7·37
Magnetite	2·78
Ilmenite	0·76
Apatite	0·34

Magmatic Name—**Yellowstonose.**

Discussing the above analyses, Mr. Card remarks:—

"A transference of the potash and lime molecules necessary for the construction of the ferromagnesian silicates will liberate a certain amount of silica, so that the percentage of quartz actually present in the rock will be in excess of that shown by the norm. The high proportion of albite molecules confirms the microscope determination of the average felspar as being a variety of oligoclase. Considering the conspicuous presence of sphene, it is rather surprising that titanic acid does not show out more prominently in the analysis.

"The analysis of the phenocrystalline orthoclase shows it to possess the usual formula, one-third of the potash molecules being replaced by an equivalent of soda. The specific gravity is a mean of the extremes allowed for orthoclase."

Sample No. 2, from the Four-mile peg on the Rivertree Road, he refers to in the following terms:—

"Porphyritic, with phenocrysts of white felspar, twinned on the Carlsbad plan. Hornblende is abundant, and sphene is readily visible. Under the microscope, certain peculiarities are noticed which differentiate this rock from No. 1. The quartz, for instance, contains a much higher proportion of cavities. It is, indeed, crowded with them (with the partial exception of the marginal zone). They may be linearly disposed, but more commonly show no arrangement whatever. The felspar of the ground-mass, again, is largely orthoclase (in place of oligoclase in 1). It shows lamellar perthitic intergrowths. Zoning and shadow extinction may be noticed. Hornblende and biotite are sometimes segregated in certain areas. *Twelve sections of sphene were counted in this one slide.*"

Students of petrology will find a couple of excellent photo-micrographs, taken by Mr. Card, with the paper describing New England rocks from which these technical descriptions are taken. The photo-micrographs show—

(*a*) A hornblende crystal in felspar; inclusions of biotite, apatite, and ilmenite, and

(*b*) A felspar crystal exhibiting strain structure.

Sample No. 3, from close to the railway station, Moonbi.—

"Not conspicuously porphyritic. Sphene readily visible. Under the microscope the general characters are much as in 1. Quartz is not crowded with cavities. Hornblende and biotite are intimately associated in places, and, together with magnetite, give rise by basic segregation to basic patches. Orthoclase and plagioclase are present. The plagioclase may contain many foreign inclusions, and may also show good composition zoning. It appears to be a variety of oligoclase. Sphene is again conspicuous, and shows some intergrowth with hornblende."

Sample No. 4, from the Moonbi Tobacco Farm—

"This type is decidedly dioritic, and differs much from those above described. It is non-porphyritic. Sphene is abundant, and can be readily obtained (sometimes in well-formed crystals) by washing the crumbling material under water. Under the microscope, one of the dominant minerals is hornblende; biotite is scarce. The hornblende is deep green in colour for the most part. It is more or less automorphic and well cleaved, and is generally locally aggregated, together with some biotite. Sphene is plentiful. There is little quartz, and practically no plagioclase. Orthoclase of perhaps somewhat larger quantity than the combined ferromagnesian silicates. The leucocratic constituents are plentifully traversed by highly elongated, transparent rods. As a hand specimen this rock would be classed as a quartz syenite."

Sample No. 5, from Walcha Road.—As regards this specimen, Mr. Card says:—

"Porphyritic, with pale flesh-coloured phenocrysts (Carlsbad twins) of orthoclase. Sphene is readily recognised. Under the microscope the general characters are much as in 1—automorphic hornblende, zonal felspar, quartz not crowded with cavities. The

felspar is occasionally very dusky, and may be crowded with inclusions of the more basic components of the rock. It shows combined Carlsbad. Albite, and Pericline twinning, and appears to be an oligoclase-andesine variety in large part. Eight or nine sections of sphene are shown in the slide, including a perfect automorph. Enclosure of sphene by biotite was noticed."

A chemical analysis of a sample of this rock (No. 5) was made by Mr. W. A. Greig, in the Chemical Laboratory of the Department of Mines, Sydney, and disclosed the following constitution:—

	Weight Percentage.
Silica	69·14
Alumina	14·74
Ferric oxide	0·70
Ferrous oxide	1·98
Magnesia	1·58
Lime	3·14
Soda	3·36
Potash	4·13
Water (100°C)	0·18
Water (100°C+)	0·38
Carbon dioxide	0·23
Titanium dioxide	0·36
Zirconium dioxide	none
Phosphoric anhydride	0·18
Sulphur trioxide	trace
Chlorine	0·04
Fluorine	?
Chromium oxide	none
Nickel and Cobalt oxides	trace
Copper oxide	trace
Manganous oxide	trace
Barium oxide	0·02
Strontium oxide	trace
Lithia	trace
Vanadic oxide	absent
	100·16
O=cl	0·01
Specific gravity, 2·696.	100·15

The norm, calculated by Mr. Card from the aforegoing chemical composition, is—

Quartz	24·78
Orthoclase	24·46
Albite	28·82
Anorthite	12·23
Diopside	1·96
Hypersthene	4·10
Magnetite	0·64
Ilmenite	0·93
Apatite	0·34

Magmatic Name—**Amiatose.**

In the Herding Yard Creek area, examined, mapped, and described by me in 1910,* this rock is traversed by numerous veins of aplite, graphic granite, and pegmatite, an interesting feature of their occurrence being the fact that they are lying quite horizontal in many instances, and are frequently so thin as to look like lace spread over the rock. In several cases it is highly probable that these veins represent the final stages of differentiation in the magma of the porphyritic granite itself rather than extrusions from the later acid granites during the curitic phase of the latter rocks. In Special Lease 05/7 and also in portion 51, parish of Ruby, county Buller, excellent examples of these acid segregations can be seen. A feature of these earlier acid veins is the production of thin veins of opaline quartz; these can be well seen traversing the porphyritic granite at Herding Yard Falls, Herding Yard Creek, Amosfield. Pegmatite veins, passing gradually into typical aplites, also abound in this rock, particularly in the area around the molar contacts; in this instance the acid intrusions are almost certainly referrable to the later acid intrusives. The veins of greisen which occur in both the "Stanthorpe" and "Sandy" granites are absent (at least so far as this region is concerned) from the porphyritic granite. The coarse-grained acid granite contains isolated patches of the porphyritic rock, but the felspars are then distinctly lighter in colour than the characteristic pink felspars of the latter variety. The sphene crystals become progressively larger and more abundant in a northerly and north-easterly direction from Herding Yard Creek, being especially well developed on Mineral Lease 327, parish of Wylie. In the case of the "Stanthorpe" granite it has been found that sphene is sometimes present in at least equal quantity to that observed in the porphyritic granite, but the crystals in the former are for the most part microscopic. Little or no botanical difference is noticeable in the Amosfield area, between the vegetation supported by these two granites, whilst the chemical analyses of typical porphyritic granite and the more dioritic (*e.g.*, Willson's Downfall) phases of the "Stanthorpe" granite show a remarkable similarity. Coarse fragments of felspar characterise the soil produced from the former rock, the corresponding fragments being much smaller in the case of soils resulting from the normal variety of the latter.

In view of the absolutely gradual change from one rock type to the other, as shown by the excellent outcrops exposed along the bed of Herding Yard Creek, the presence at times of

* Mineral Resources of New South Wales, No. 14, p. 89

microscopic sphene in the coarse acid granite, and also their frequent agreement in chemical composition, I formed the opinion in 1910* that the porphyritic granite should be classed as simply an extreme variation of the "Stanthorpe" granite, a theory which I still hold. However, in view of the statements of Mr. Andrews that he has personally seen in certain New England districts evidence that it is a distinct rock intrusion, and also as in typical areas the two rock types are very strongly differentiated, the porphyritic granite has been mapped as a distinct granite intrusion. It is probable that these two rocks were nearly, if not actually, contemporaneous.

In order to ascertain as true an average sample as possible, chips of fresh rock were taken by me in 1910 from a great number of outcrops scattered over a large area from the Herding Yard Creek occurrence, and the sample submitted to the New South Wales Geological Survey Laboratory. Mr. W. A. Greig's investigation gave the appended chemical composition:—

	Percentage Composition.	Molecular Ratio.
Silica	68·25	1·137
Alumina	14·41	140
Ferric oxide	2·00	13
Ferrous oxide	2·07	29
Magnesia	1·08	27
Lime	3·06	54
Soda	3·19	52
Potash	4·74	50
Water (100°C)	0·19	..
Water (100°C+)	0·35	..
Carbon dioxide	0·05	..
Titanium dioxide	0·36	..
Phosphoric anhydride	0·15	..
Sulphur trioxide	absent	..
Chlorine	absent	..
Fluorine	absent	..
Chromium sesquioxide	absent	..
Nickel and Cobalt oxides	†traces	..
Manganous oxide	0·16	..
Baryta	0·03	..
Zirconium dioxide	absent	..
Strontia	‡present	..
Lithia	‡present	..
Vanadium sesquioxide	absent	..
Copper oxide	0·01	..
	100·10	

Specific gravity, 2·698. No gold or silver present.

* Mineral Resources of New South Wales, No. 14, pp. 88, *e tseq*

† Less than 0·01 per cent.

‡ Spectroscopic reaction only.

Calculating from this analysis, Mr. Card obtained the following norm for the average composition of the rock as seen in the district named:—

Quartz	23·40
Orthoclase	27·80
Albite	27·25
Anorthite	10·56
Diopside	2·77
Hypersthene	3·75
Magnetite	2·09
Ilmenite	0·61
Apatite	0·34

Small faultings, with a displacement, ranging from an inch to one foot, occur in the granite masses and graphic granite, &c., veins along Herding Yard Creek.

As stated in the early part of this chapter, a marked feature of this rock is its great wealth of basic segregations. That this might perhaps represent highly altered slate fragments embedded in the intrusive porphyritic granite would be suggested by a casual inspection, but closer examination reveals the fact that odd porphyritic crystals of felspar occur in the centre of these darker masses of basic material. For a good description of these inclusions, reference should be made to the several interesting papers by Mr. Andrews in the New South Wales Geological Survey Records quoted previously. A photograph, taken by the writer, of a typical occurrence showing a large basic segregation in the porphyritic granite appeared in Mr. Carne's tin monograph, already referred to (Plate VIII.), whilst the great size attained by the individual phenocrysts of felspar can be seen in Plate IX. of the same publication. The appearance presented by these numerous basic segregations has been well likened to a patch-work quilt.

Where seen in large exposed blocks this rock has a distinct tendency to form "tors," as in the case of the coarse acid granite.

No tin or other commercially valuable metal has as yet been discovered actually in the porphyritic granite or the acid veins by which it is traversed. However, as stated previously, I am of opinion that the great beauty of this rock thoroughly warrants its inclusion in the list of high-class building stones for the ornamentation of buildings.

The Biotite Granite (the "Maryland" Granite).

Although no outcrop of this rock has been noted by me on the Queensland side of the range, it nevertheless occurs so close thereto (at Maryland) that it has to be included in any description of the Stanthorpe-Willson's Downfall petrographical province. The following account of this formation is largely taken from my already published description.* This rock has been designated the Maryland Granite, owing to its development within the area mapped, being represented by a relatively small semi-circular outcrop, commencing at the Maryland Station Homestead, and extending for a distance of about 1¾ miles in an easterly direction therefrom. Mr. Card classifies this rock as a biotite granite belonging to the variety known as *Adamellite.*

It intrudes the ancient dioritic rock of Baker's Hill, and appears to be in turn itself intruded by the "Stanthorpe" granite on portion 24, parish of Maryland. It is a fine to medium grained greyish blue rock, with abundant quartz and biotite, and produces a good type of grazing land. Numerous basic segregations (much smaller than those seen in the porphyritic granite just described) are scattered irregularly through the outcrop; these frequently weather out of the harder main rock mass with the production of potholes, such feature being readily observed among the blocks forming the bed of Maryland River in the village of Maryland. It is marked by rounded bouldery outcrops with a general tendency to form tors. On portion 24 of the parish of Maryland it is intruded by thin veins of aplite and graphic granite accompanied by many small pegmatite veins.

Its junction with the surrounding rock masses is unfortunately cloaked for the most part. The soil produced is buff to grey in colour, producing open park-like land; area of outcrop approximately 2½ square miles.

The "Maryland" granite boss (?) is characterised by a rather distinctive flora, apple-tree, grey gum, and white gum being among the commoner representatives, whilst the outcrop is marked by an abundance of a reddish yellow fungoid growth which apparently displays a preference for this rock, being rarely observed on the surfaces of the other formations seen in this district.

The rock mass preserves a fairly constant facies wherever exposed. The quartz usually weathers into relief, exhibiting a low honeycombed structure.

* Mineral Resources of New South Wales, No. 14, page 91.

In addition to the occurrence above described very small isolated patches of this rock were found, adjoining the Maryland road, three-quarters of a mile from the Two-mile Creek road crossing.

In some respects this rock shows a great similarity to the granite (named the "Tingha" granite) occupying large areas in the Tingha (N.S.W.) tinfield, which was examined by the writer in company with Messrs. J. E. Carne, Assistant Government Geologist of New South Wales, and L. A. Cotton, B.A., B.Sc., Macleay Fellow of the Linnean Society in Geology.*

No mineral deposits have as yet been found genetically connected with this granite.

Quite recently I have been shown a sample of granite which the Public Works Department are about to use in certain buildings at Warwick; the specimen comes from one of the bouldery outcrops seen close to the Greymare Railway Station, 20 miles beyond Warwick, on the South-Western Line, at an elevation of 1,496 ft. above sea-level. It resembles the Maryland granite to such a marked degree in hand-specimens that it may ultimately prove to represent an outcrop of this rock

PALÆOZOIC.

PERMO-CARBONIFEROUS.

The "Blue Granite."

The intrusions classified under the name of the "Blue Granite" are represented in the Wallangarra district by a pear-shaped mass surrounded by the felspar porphyry on the west, south, and east, and by the "Stanthorpe" granite on the north. Its gentle, rolling country, composed of good red and chocolate soil of a greasy nature, mark it out strongly from the neighbouring rock types enumerated; orchards and farms are dotted over this formation much more numerously than in the case of the surrounding rocks.

* Mineral Resources of New South Wales, No. 14, pp. 22, &c., and Proceedings of the Linnean Society of New South Wales, 1909, Vol. XXXIV., Part 4, pp. 742, &c.

Numerous now isolated outcrops of this once much more extensive rock occur over New England, perhaps the most important being those seen at Tenterfield, Bolivia, Emmaville, Deepwater, and Tent Hill.

Wherever seen this rock presents a markedly basic facies as compared with the other granitic intrusions. In fact, it might easily be considered as a diorite in places, the silica contents being about 64 per cent. (*c.f.* the analyses of the acid granites given in the previous chapters). Micro-granite, dacite, quartz-porphyry, and other names have been applied to this rock in different localities.

Excellent outcrops of this formation can be seen close to the railway line to the north of Bald Mountain Siding, and along Accommodation Creek (in the parishes of Tenterfield and Ballandean).

Concerning the different masses of this rock he has seen, Mr. Andrews states that throughout New England "a marked persistency of texture and composition is noticeable. The same wonderful platy exfoliation, strong rectilinear jointings, spheroidal tors, greasy chocolate soil, and development of narrow epidotised veins, occur in all." That description aptly applies to the Wallangarra area also.

Its geological age, relative to the other rocks in this petrographical province, has been set down by me as Upper Bowen (?) seeing that its period of intrusion is about the close of the Permo-Carboniferous and probably since the deposition of the Lower Bowen slates, &c., but in no instance known to the writer does the "Blue Granite" occur in such a position that its relationship to the Lower Bowen can be established. It certainly intrudes the grey felspar porphyry, which is described in the succeeding chapter. Mr. Andrews ascribes it to a laccolithic or sill origin.

Eucalyptus viminalis, E. coriacea, E. nova anglica, E. conica, and *Angophora intermedia* are mentioned as characterising this rock.*

In places this rock-mass exhibits signs of the original magma having undergone a fair amount of differentiation, as shown by the presence of large basic segregations, which Mr. Andrews has observed to be associated with more acid inclusions having a decidedly fluxional arrangement.

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* Records of the Geological Survey of New South Wales, Vol. VIII., Part 3.

The actual boundary between the later "Stanthorpe" granite and this rock is usually defined in the Wallangarra area, but along the line of junction with the older porphyries it is difficult to assign anything other than an approximate boundary owing to the extreme entanglement of these two formations. The southernmost portion of the outcrop, on the border line between the two States, is very narrow for a few chains, being really dyke-like at this point.

Mr. Card's petrological descriptions of typical samples of this rock from the various areas are appended:—

Sample 1, from 2 miles east of Tenterfield.† "Dioritic in appearance. Colour, bluish-grey. Automorphs of biotite, averaging about a millimetre in diameter, are abundant. The porphyritic texture, and the presence of a base, are barely recognisable in the hand-specimen, the appearance being that of a uniformly fine-grained holocrystalline rock."

"Under the microscope a micro-granite groundmass is seen,* in which are embedded abundant phenocrysts of felspar, quartz, biotite, and augite. These are to a large extent corroded and shattered. *Felspar* is fresh, and shows zoning and twinning (Carlsbad and Albite types). It is probably a variety of oligoclase. Among the minerals enclosed by it are biotite, acicular colourless crystals, and acicular crystals (perhaps tourmaline), pleochroic in tints of blue. Foreign particles may be zonally arranged. Strain shadows are occasionally seen. *Biotite* is deep brown in colour. The crystals are frequently bent and the extinction angle in such cases more or less deflected locally at the position of bending. Magnetite, and also felspar, is enclosed by it. The *Pyroxene* (Augite) is green and yellow in colour, and may be altered with development of iron ores. It encloses biotite.

"Hornblende, zircon, and other minerals are present in this rock, but not well displayed in Sample 1.

"Regarded as a hand-specimen only, it would be variously classified as eurite, granite-porphyry, quartz-felspar-porphyry, or micro-granite."

† This outcrop is identical in character with that of the Wallangarra district, from which it is only a few miles apart.

* In the other varieties described below, the texture of the groundmass is much less defined, and becomes distinctly cryptocrystalline."

An analysis of this rock (J. C. H. Mingaye, Analyst) made in the Chemical Laboratory of the Geological Survey (N.S.W.) gave the following result:—

	Weight Percentage.	Molecular Ratio.
SiO_2	65·36	1·089
Al_2O_3	16·37	·161
Fe_2O_3	1·80	·011
FeO	2·68	·038
MgO	1·81	·045
CaO	3·82	·068
Na_2O	3·40	·055
K_2O	3·75	·039
H_2O (100° C)	0·09	...
H_2O (100° C+)	0·33	...
CO_2	none	...
TiO_2	0·36	·004
ZrO_2	trace	...
P_2O_5	0·16	...
SO_3	none	...
Cl	0·05	...
F	0·14	...
S (FeS_2)	none	...
Cr_2O_3	trace	...
NiO, CoO	none	...
CuO	none	...
MnO	0·16	·001
BaO	0·14	·001
SrO	trace	...
Li_2O	trace	...
V_2O_5	trace	...
	100·42	
O Cl	0·07	
	100·35	

Specific gravity, 2·71.

Calculating from the above analysis, the following norm was obtained by Mr. Card:—

Quartz	19·9
Corundum	0·5
Orthoclase	21·7
Albite	28·8
Anorthite	17·2
Hypersthene	2·7
Magnetite	2·5
Ilmenite	0·6
Fluorite	0·3
Apatite	0·3

Magmatic name—**Toscanose.**

Sample No. 2, from the 4-mile peg on the Nine-mile road, Deepwater. Mr. Card thus describes this rock:—

> "The groundmass is quite cryptocrystalline, and also shows signs of fluxion. Among the phenocrysts is one that may be orthoclase. Occasionally, however, the mottled appearance between crossed nicols and a feeble striation indicate the possibility of an orthoclase being present. Numerous small fragments of the

minerals occurring as phenocrysts are scattered through the ground-mass. A vein of epidote was noticed, as also an included fragment of lava. Automorphic hornblende is present."

Sample No. 3, from Emmaville, he refers to as follows:—

"The felspars are markedly zonal. Segregation groups of pyroxene and biotite occur. Both hornblende and pyroxene may be automorphic. Quartz (corroded) is a distinct feature, although still quite subordinate to felspar. Zircon is present."

Sample No. 4, from Wellington Vale, between Deepwater and Emmaville, he describes as under:—

"Composition zoning—basicity increasing outwards—is common in the felspar phenocrysts. Orthoclase is possibly present. In one instance an accurate determination of a plagioclase phenocryst was possible, when it proved to be an acid variety of labradorite. Hornblende is present. An instance of complete envelopment of biotite by a quartz individual was noticed."

Sample No. 5, from near the Bolivia Railway Station, he describes:—

"The groundmass here verges on cryptocrystalline. Quartz is conspicuous, occurring as typically corroded automorphs. Felspar is none the less the dominant phenocrystalline constituent, and appears to comprise species as basic as andesine. It is sometimes mottled between crossed nicols. Biotite is a prominent constituent, and very deep in colour, but sometimes has a narrow green selvage. Apatite occurs in the groundmass, as well as in the ferromagnesian silicates."

After an examination of the various types of this rock submitted to him, Mr. Card expresses the opinion that "textually considered, it is evident from the corrosion of the phenocrysts and the occasional indication of fluxion, that the crystalline character of the groundmass is due to devitrification and is therefore not original. It seems also probable that the bending of biotite, the molecular strain in biotite and felspar, and the shattering of various minerals, are due to movements in the groundmass before its consolidation."

This rock has been found in natural sections to be at least 800 ft. thick in the Tenterfield district, which is rather strange when account is taken of the abundant cryptocrystalline groundmass.

So far as ore deposits are concerned, nothing of value has yet been found in this formation, nor is it thought that the rock is genetically connected with the deposition of any commercially valuable metals. However, the excellent soil which it produces on decomposing is more than a saving grace.

Lower Bowen Sedimentaries—

Following the classification now being published in the "Queensland Mineral Index"* (by B. Dunstan, Government Geologist), a *Lower Bowen* age has been assigned to the great series of marine slates, conglomerates, limestones, shales, sandstones, schists, and quartzites, and volcanic tuffs, and breccias occurring to the west of the Stanthorpe district granite areas. Fossils are extremely rare in this formation, but those found up to the present point to marine conditions of sedimentation having obtained throughout the area under review. In 1907, Mr. J. E. Carne, Assistant Government Geologist of New South Wales, obtained the following Permo-Carboniferous forms, probably of *Lower Marine* age (according to the New South Wales Geological Survey classification) from railway cuttings near Warwick:—

Productus brachythærus, G.B. Sby.

Spirifera stokesi (?), Konig.

Martiniopsis subradiata, var. *Morrisii, Eth. fil.*

Crinoid stem.

In the year 1905 the three fossils enumerated below were obtained "from highly folded rocks along the Clarence River, a few miles below Rivertree"†:—

Productus subquadratus, Morris. (Similar to form occurring at Mount Britton, in Queensland).

Eurydesma cordata, Morris.

Deltopecten sub-quinquelineatus, McCoy.

Mr. W. S. Dun, Palæontologist, considers that these forms indicate a Lower Marine age for the beds.

In 1899, Mr. H. G. Stokes, then manager of the Silver Spur Mine, near Texas, contributed a paper to the North of England Institute of Mining and Mechanical Engineers,‡ in which he

* G.S.Q. Publication No. 241.

† "Report on the Drake Gold and Copper Field" (E. C. Andrews), being Mineral Resources of New South Wales, No. 12, p. 10, 1908.

‡ "Ore Deposits of Silver Spur."

makes mention of the fact that he obtained certain Permo-Carboniferous marine fossils from this formation in the Silverspur district; unfortunately, this paper has not been available to the writer. Fragments of crinoid stems have been found from time to time in the limestone beds in that district.

As elsewhere throughout northern New South Wales, the Permo-Carboniferous strata have here been intruded by the acid and other granites described in aforegoing chapters. Mr. E. F. Pittman, Government Geologist of New South Wales, was the first to record the intrusion of the Permo-Carboniferous Coal Measures by the granites.*

In his Report on the Drake district, already referred to, Mr. Andrews propounds the following query:—"What is the relation of the Gympie (?) beds of the Queensland geologists to the Northern New South Wales Lower Marine beds?"

The latest classification adopted by the Queensland Geological Survey† places the Queensland beds, as developed at Warwick, in the Lower Bowen Series; as regards this area, it may be taken that the beds constitute simply a former continuation of the Lower Marine beds of New South Wales, prior to the post Lower Marine granitic intrusions. It should be borne in mind, however, that the formation known as Gympie is not to be replaced everywhere throughout Queensland by the Lower Bowen, but only in so far as it refers to the area here being considered.

Perhaps the best recent addition to our knowledge of the conditions obtaining during the deposition of the Lower and Upper Marine Series of the Permo-Carboniferous is that published during the present year (1913) by Mr. A. B. Walkom, B.Sc., Linnean Macleay Fellow in Geology, Sydney.‡ That paper is accompanied by several sketch maps, giving the author's interpretation of the coast lines existing at the time the marine beds were laid down. He assumes some subsequent tangential thrust from an easterly direction which would produce (*a*) a north-south warp in the marine sediments, accompanied as a natural result by (*b*) a depression to the westward in which the coal measures were deposited.

* Records of the Geological Survey of New South Wales, 1896-98, V., pp. 26-30.

† "Queensland Mineral Index" (1913).

‡ Stratigraphical Geology of the Permo-Carboniferous system in the Maitland-Branxton district, with some notes on Permo-Carboniferous Palæogeography in New South Wales," being Proceedings of the Linnean Society of New South Wales, 1913; volume XXXVIII., Part 1, pp. 134 *et seq.*

Mr. W. S. Dun, Palæontologist to the New South Wales Geological Survey, is of opinion that certain of the fossil collections from the northern New England areas indicate an amalgamation of both Upper and Lower Marine types; this fact points to the continuous deposition without any appreciable lapse of time between the two formations of all the Marine Series in this region.†

It is interesting to note that as early as 1872 the highly important fact that the sedimentary rocks in this district are intruded by the granites was practically stated by Mr. W. C. Hume, Mineral Lands Commissioner at Stanthorpe, in his report on "The Queensland Tinfield," already mentioned in the introductory chapter of this bulletin. His report contains the following statements:—

> "Regarding the age of the granite I can but state that it appears to underlie all other rocks in this part of the country. I think this because we find it underlying the slate at the Red Rock, and on descending the ranges for 1,000 ft. towards the river, we again come upon it, leading to the inference that the heavy slate ranges in that locality may simply be the result of upheavals of the granite. In 1866, I came upon granite boulders cropping up out of the slate, on the Severn River, more than 60 miles west of this, the intermediate country being slate. The Red Rock merits special attention, exhibiting more promising indications than in any other locality; on a gully running north-west into the Severn River, and in slate country, at an elevation of 3,000 ft. above the sea, an irregular patch of granite occurs which appears to have been intruded through the over-lying metamorphic rocks."

Ironbark timber is perhaps the most abundant on this formation, and it is worthy of note that the only occurrences of the red-flowering variety of this tree known to the writer are confined strictly to these rocks. In the Elsmore-Newstead portion of the Tingha Tinfield (N.S.W.), this tree (red-flowering ironbark) occurs under conditions absolutely identical with those seen in the Stanthorpe areas—namely, growing on ridges of the so-called "Trap" rocks (sedimentary), which latter formation is intruded by the "tin-granites." Much of the country occupied by this formation yields a clayey soil that grows grass in sufficient quantities to cause it to be classed as fair "sheep country";

† Mineral Resources of New South Wales, No. 12, p. 7, 1908.

Pikedale, Glenlyon, Gunyan, and many other well-known station properties are situated on outcrops of this formation.

Limestone belts, mostly of relatively small extent, occur in several places through the sedimentary beds, notably at Glenlyon, Silverspur, Limevale, Kilminster, &c.

Outcrops of ironstone are usually present in juxtaposition to the limestone belts, as at Silverspur.

A well-marked outcrop of conglomerate occurs close to the old Pikedale Mine, Pikedale.

Owing to the frequent presence of much interstitial water, this rock has been known to shatter into fragments if cooled suddenly after great heating—*e.g.*, when water has been accidentally spilled on to a hot fireplace constructed of blocks of this

PLATE 10.—FINE-GRAINED TUFF. [*Photo., R. Graf.*

Showing numerous quartz veinlets resulting from a neighbouring intrusion of granite.

sedimentary formation; this phenomenon has been most frequently observed in the case of the very fine-grained tuffs.

Numerous boulders of granite and other rocks are found embedded in this formation; reference to these will be found under the description of Silverspur.

Owing to its excessive hardness and resistance to the

weathering agencies, the topography resulting from this formation is marked by a much greater unevenness of surface than obtains for the intruding granite masses. Especially along its eastern edge this change from granitic to sedimentary rocks is noticeable; *e.g.*, near Ballandean Station homestead. This result has been largely brought about by the very considerable addition of silica from the invading granitic magmas. Towards the head of Pike's Creek this feature is accentuated by the presence of an immense number of veinlets of white quartz through the sedimentary strata. The accompanying photograph (Plate 10), approximately natural size, of a hand specimen from this locality, will illustrate this structure. The rock is a fine-grained tuff.

Chiastolite has been developed in the slates at their junction with the "Stanthorpe" granite, on Mr. Bambery's property, Ten-mile Creek.

Along the periphery of the sedimentary formations, at the junction with the intrusive granites, are found numerous lode tin, wolfram, and molybdenite veins, this being well instanced at Red Rock. Lode tin (along a cleavage vein) occurs in slate country at Sundown. The silver-lead-zinc-copper lodes of Silverspur district, and the Waroo and Pikedale gold mines are located in this formation, as also are the gold mines of Thane's Creek, Talgai, Leyburn, Canal Creek, Palgrave, and Lucky Valley, in the Warwick district.

The various groups of sedimentary rocks classed as Lower Bowen are known locally under the general name of "Trap," from an incorrect nomenclature adopted by the early tin miners in Tingha and Vegetable Creek (Emmaville), N.S.W. Owing to the great hardness characterising this rock in consequence of the granitic intrusions, and also its usually blue colour, it was mistaken for basalt, and hence the English miners named the formation "trap." Although subsequently shown to be of sedimentary origin, the name of this rock series was never altered locally, and hence its application to the similar rocks seen in the Stanthorpe Tinfield by the tin miners, many of whom had previously been working on the Southern fields.

PRE-PERMO-CARBONIFEROUS.

Acid grey felspar-porphyry.—A rudely triangular-shaped mass of this rock occupies by far the greater portion of the Wyberba, Bald Mountain, Wallangarra, and Donnybrook districts, in the extreme southern portion of the area examined (*vide* Map No. 3).

This formation has been clearly intruded by the "Blue Granite," the "Stanthorpe" Granite, and the Porphyritic (sphene-bearing) Granite. Its eastern and northern boundaries have been fairly closely mapped, but the western portion has, owing to the exigencies of travel, the very limited time at my disposal, and the absence of any genetic relationship to the tin deposits, been shown very approximately only. Along its north-eastern edge it follows the main southern railway line and Accommodation Creek closely for several miles, crossing the line between Wyberba and Lyra railway sidings. The most northerly outcrop seen by me is about 2 miles west of the latter siding, whilst its southern extension into Sunnyside and Tenterfield has been noted by Mr. Andrews.*

In Portion 84, Parish of Ballandean, an outcrop of Lower Bowen altered sedimentary rock appears to overlie this formation along the State border; this would make the porphyry of older age than the Lower Bowen, which is in accord with its geological sequence elsewhere.

From the fact that considerable areas of volcanic breccias and agglomerates composed of apparently similar rocks have been found at Mount Bajimba, this formation is in all probability of the nature of a lava flow. Its occurrences in the Wallangarra district strongly support this view.

A typical sample of this rock, from a spot two miles east of Tenterfield, and identical with that seen on the Queensland side of the border, has been thus described by Mr. G. W. Card, Petrologist to the New South Wales Geological Survey*:—

> "Porphyritic micro-granite: Not conspicuously porphyritic, with small phenocrysts of buff-coloured felspar. Under the microscope, the groundmass is distinctly micro-granitic. The phenocrysts are much altered. Those of quartz are shattered, and show typical groundmass corrosion. It is evident, therefore, that the crystalline character of the latter is due to intense devitrification. The felspar phenocrysts are too dusky for examination. A few grains of magnetite are present, and the groundmass contains occasional nests of mica."

* Records of the Geological Survey of New South Wales, Vol VIII., Part 3

A chemical analysis of this rock was made in the Chemical Laboratory of Department of Mines, Sydney, by Mr. J. C. H. Mingaye, who furnished the following result:—

	Weight Percentage.	Molecular Ratio.
SiO_2	73·68	1·228
Al_2O_3	15·06	·148
Fe_2O_3	0·68	·004
FeO	0·54	·007
MgO	0·26	·006
CaO	0·54	·009
Na_2O	3·36	·055
K_2O	5·45	·059
H_2O (100° C)	0·18	...
H_2O (100° C+)	0·28	...
CO_2	0·01	...
TiO_2	0·16	·002
ZrO_2	none	...
P_2O_5	0·11	·001
SO_3	none	..
Cl	none	...
F	none	...
S (FeS_2)	none	...
Cr_2O_3	none	...
NiO, CoO	none	...
CuO	none	...
MnO	0·07	...
BaO	0·04	...
SrO	trace	...
Li_2O	none	...
V_2O_5	none	...
	100·42	

Specific gravity, 2·658.

Calculating from the above figures, Mr. Card obtained the norm, as follows:—

Quartz	31·5
Orthoclase	32·8
Albite	28·8
Anorthite	1·7
Corundum	2·9
Hypersthene	·7
Magnetite	·9
Ilmenite	·3
Apatite	·3
	99·9

Magmatic name—**ALASKOSE.**

This rock is believed to belong to the same series as certain acid porphyries at Mounts Bajimba and Spiriby, Wandsworth, Glen Innes, Dundee, Emmaville, Inverell, Booroolong, Glencoe, &c.*

Mr. Andrews considers these lavas to be Carboniferous, or possibly of the same age as the Permo-Carboniferous lavas (trachytes, andesites, and felsites) of the Drake district.

* Records of the Geological Survey of New South Wales, Vol. VIII., Part 3.

A good proportion of the rocks classified under this heading consist of devitrified rhyolites, some of which show small phenocrysts of quartz and felspar. The soil produced by the decomposition of this lava is yellowish to white in colour, and composed largely of clayey material; it supports a moderate class of timber and also fair grass (especially for cattle-raising).

The topographical forms developed, notably in the southern portion of its outcrop in the neighbourhood of Donnybrook, are high rugged ridges which present considerable difficulties as regards travelling; at times, as between Bald Mountain and Wallangarra, it forms undulating country.

This formation, which has a characteristic slatey appearance and is usually grey in colour, is included locally under the general name of "trap" (*vide* previous chapter). It frequently has quite a mottled appearance from the abundance of small felspar phenocrysts set in a bluish-grey groundmass. No tin or other metals of commercial value have so far been detected in this rock, although some shaft-sinking was carried out on a white quartz reef on Werner's ground, near Wallangarra.

Altered Diorite, Grano-diorite, Hornblende-granite, &c.

This bluish to black rock, which makes its appearance on the New South Wales side of the range, occurs as numerous isolated outcrops (usually hills) disposed along a north-western line from the village of Liston to the village of Maryland; by far the largest outcrop being that which forms the prominent Baker's Hill, near Maryland Station homestead.

It is characterised by the production of good red soil supporting an excellent pasturage and good timber trees.

Perhaps the most interesting outcrop of this remnant of an old formation is that exposed in the bed of Herding Yard Creek (Portion 53, Parish of Ruby, County Buller), where it can be seen to be intruded by offshoots from all the granite masses by which it is surrounded. The wonderful system of anastomosing veins of aplitic pegmatite, graphic granite, &c., which here traverse this formation, render the resultant rock, in the writer's opinion, one of the most remarkable geological structures to be seen in any part of the whole granite plateau. The accompanying notes in reference to this rock type are extracted from my report on the Willson's Downfall-Maryland Tinfield.*

* Mineral Resources of New South Wales, No. 14, pp. 87-88.

At the north-east corner of Portion 62, Parish of Ruby, six miles north-west of Willson's Downfall, occurs a low hill, composed of augitic diorite, which Mr. Card describes as follows:—

Augitic diorite.—"Under the microscope, made up of about equal proportions of rather dusky plagioclase and pale green hornblende. The presence of residual pyroxene indicates that part at least of the hornblende is secondary. A little magnetite."

This rock presents considerable differences in structure, passing by insensible gradations from mica-diorite, quartz-diorite, and grano-diorite into a hornblende granite. An excellent illustration of the variations shown by this rock is visible in the bed of Herding Yard Creek, on Portions 52, 53, and Special Lease 05-7, Parish of Ruby, where, in the bed of the stream it is a mica-lamprophyre, but when followed in an easterly direction up a low ridge, it becomes progressively more acidic and coarser in texture. The following additional technical descriptions have been furnished by Mr. Card on typical samples of this rock secured from different portions of the mass, and indicate the variation in question:—

Mica-Lamprophyre (Minette).—"A microcrystalline, glistening gray rock, breaking with an uneven fracture. Some patches of quartz present. Under the microscope, orthoclase predominates, the other constituents being biotite, hornblende, augite, and apatite. A little plagioclase is probably also present. The orthoclase shows zoning."

Quartz-diorite.—"Fine-grained. Under the microscope, made up of approximately equal amounts of dark and light coloured constituents. Consists essentially of felspar and hornblende, with quartz, biotite and magnetite as accessories, and veins of secondary epidote. The felspar is much clouded, but seems to be almost entirely plagioclase."

Grano-diorite.—"Under the microscope, coloured constituents (biotite and hornblende) make up nearly one-half the rock. Quartz is subordinate, and plagioclase greatly exceeds orthoclase. Sphene, magnetite, pyrite, and apatite are accessories."

Grano-diorite.—"Under the microscope, dark and light coloured constituents are about equal in proportion. Of the felspar, a rather basic plagioclase is strongly dominant over orthoclase. Quartz is subordinate. Hornblende and biotite present, former in excess of

the latter. As accessories, sphene, apatite, and magnetite. Apatite is locally abundant and occurs as conspicuous long needles."

Hornblende-granite.—"Under the microscope, the predominating mineral is felspar, and the ratio of plagioclase to orthoclase is so high as to bring the rock under the grano-diorite class. The felspar is in part cloudy. Quartz is subordinate. Hornblende and biotite in considerable quantity, the former predominating. As accessories, sphene and apatite both occur as conspicuous crystals, and in comparative abundance."

The main outcrop of this rock is that area, approximately circular in shape, which is seen to extend from Tompkin's Gully across the Maryland River to near the south-eastern portion of the village of Maryland, with the high peak of Baker's Hill (3,500 ft. above sea level) forming the centre. The boundaries of this formation are mostly cloaked, with the exception of a very small patch of rock in the bed of Maryland River, in Portion 266, Parish of Maryland, where the diorite can be seen to be intruded by the "Maryland" granite. Small veins of granite and quartz can be seen intruding the rock in places along the western slope of Baker's Hill. It appears to intrude the granulite (*vide* next chapter) near Maryland Station homestead.

No commercially valuable metals have so far been found to occur genetically in this formation, though, of course, small quantities of alluvial tin have been won many years ago from the bed of the Maryland River, but this material clearly represents tinstone denuded out of the adjoining stanniferous granite areas and not from the dioritic rock itself.

Granulite:—

The former area of this rock seen in the region covered by this report has been greatly circumscribed by the intrusions of the "Stanthorpe" and "Maryland" granites, as also by the older diorites. Only two isolated masses of this formation have been observed, the principal one being that stretching from (and including) the village of Maryland north-westerly to the extreme northern portion of the Parish of Stanthorpe, about 3 miles north of Thulimbah. Granulite mostly produces moderate grass country, but the area locally known as the Wallaroo Hills, as its name signifies, consists of harsh jagged rocky outcrops, especially along the Maryland River. This formation is included under the local name of "Trap."

The intrusion of this rock by the "Stanthorpe" granite is well seen in the bed of the last-named stream in Portion 461,

Parish of Maryland. It shows unmistakable signs of having been subjected to intense compression, with the production of well marked cleavage lines. Schistosity is evidenced by the abundant mica schists seen along the edges of its extreme easterly extension through Portions 50, 28, 29, &c., Parish of Maryland.

From its appearance and resultant soil this formation had always been mistaken by geologists for a true sedimentary rock, but microscope investigation by Mr. Card, in 1910, revealed the fact that it belongs to the granulite family. Partial recrystallisation of the rock material subsequent to the crushing can be seen under the microscope.

From the village of Maryland westwards and northwards the granulite occupies the whole of the area forming the headwaters of the Maryland River and its tributary, Ram's Swamp. The rock in the latter locality is remarkably like a quartzite, and the very careful microscope examination of a number of typical specimens had to be made in order to establish its present geological designation. In this area also it is decidedly schistose in places, and in the abandoned stone quarry situated close to the south-west corner of Portion 64, it presents all the appearance of a bedded sedimentary rock, much folding and crumpling accompanied by minor faultings having taken place.

Along the border range this rock much resembles a basalt; in fact, Mr. Hume, in his report to which reference has already been made, had considerable difficulty in assigning a name to this formation. In one portion of his description he refers to it as a diorite-slate, and in another part he states that around Maryland he was often in doubt as to whether the rocks were slates, jointed greenstones, or basalt. In my opinion they represent the extreme metamorphism of a former sedimentary series which pre-existed all the other formations seen in this petrographical province. Nothing at all resembling a fossil has ever been seen in this rock, and even if such had ever existed, the extreme alteration to which it has since been subjected would, in all probability, have entirely obliterated all traces of former life from which the age of the rocks might be adduced.

In the neighbourhood of Maryland Station homestead, and along the Maryland River, this rock has been intruded by numerous dioritic dykes, some of which show a marked resemblance to the dioritic rocks seen at Baker's Hill (*vide* previous chapter).

No minerals of commercial value have been found in this formation, with the exception of a small quartzose vein of tin ore in contorted rocks at Quarry Hill, Portion 64, Parish of Maryland.

CHAPTER V.

ECONOMIC GEOLOGY.

Part I.—STANTHORPE DISTRICT.

As pointed out above, the *Recent* stanniferous alluvials mined in this district have already been described in great detail in the several reports which are listed in the introductory chapter, and as no useful purpose could be served by again publishing descriptions of long-since abandoned claims, it is not the intention of the writer to give descriptions of anything other than the more important operations now (1913) in progress—viz., the present dredging and alluvial claims.

SUGARLOAF CREEK.

Sugarloaf No. 1 Dredge.—This plant, owned by Mrs. Allison, of Sugarloaf, is (July, 1913) working on portion 406, parish of Folkestone, Sugarloaf Creek, 8 miles east of Stanthorpe. It is intended to also work it on portion 590. Mr. James Shannon, manager.

This dredge, as in the case of the Dalcouth and Lode Creek plants, is on a barge, and was built by Messrs. A. Thompson and Company. The description is as follows:—Outside measurement of barge, 30 ft. by 35 ft.; total weight, 90 tons; depth of water required to float the plant complete, about 3 ft. 6 in.; 3½ and 4 in. nozzles; two 10-in. pumps; one 50-h.p. compound horizontal engine; one 50-h.p. multitubular boiler (18 by 7 ft.); surface condenser; 120 ft. of boxes—width 7 ft., depth 2 ft. 6 in. ("fall" allowed to boxes ⅝ in. per ft.); dynamo and electric light plant. The plant is rope-driven; cost of plant, fixed and ready to work, £3,200. Working seven men on each shift (two shifts of eight hours each), in twenty-four shifts 3,500 cubic yards are removed.

The fuel consumption is 20 cords of 6-ft. firewood per week, the material burned consisting of half stringybark (dry) and half gum (green). It has been found here that the best steaming capacity is obtained from the green timber after having been

stacked for six weeks. Cost of firewood, 5s. per cord for cutting and stacking, the management providing the two carters necessary.

The use of explosives for loosening the tight ground and "cement" renders costs slightly higher than in loose sandy ground; it is intended to use black powder in the future for this purpose, as it is thought that the same efficiency can be obtained from this cheaper material as from one or other of the special explosives previously employed.

Spiral pipes (made by Mephan Ferguson) have been found to give satisfactory results, being very light and easy to manipulate.

The average depth of the ground being treated at the time of my visit was 8 ft., but the depth of overburden appeared to be increasing perceptibly as followed upstream. The material then being dredged consisted of 2 acres of stiff black clay resting on sand, which in turn overlies patches of washdirt (the main portion having been mined many years ago). Upstream the dark clay disappears, the overburden being practically all loose sand. The "bottom" is mostly soft granite and comparatively even. The tinstone is medium-grained black and ruby; very little black sand or gemstones remain in the sluice boxes. On block 590 a few flakes of gold were got from the surface deposits.

There is estimated to be at least seven years' work ahead of this plant.

A large tailings dam assures an abundant supply of water, being fed by a considerable catchment from the border range.

It is intended to erect a second and more powerful plant on portions 557, &c., in the near future.*

Operations with the No. 1 plant commenced in January of the present year (1913), since when the following quarterly yields of tin have been recorded to June, 1913:

			Tons	cwt	qr.	lb.		
1913—Jan. to Mar.,	10,884	c. yds. of material treated for	4	16	1	0	worth	£719
Apr. to Jun.,	20,250	,, ,, ,,	6	8	2	10	,,	976
Total ...	31,134	,, ,, ,,	11	4	3	10	,,	£1,695

For the class of material treated, the extent of ground available for dredging, the character of the bottom, &c., a barge here is of more use than a portable plant, but in most other areas seen by me such a plant would not give the same satisfaction as do the portable variety in this district.

* A dredging plant is now (1914) in commission here.

A fair amount of very shallow "surfacing" has been worked for tin hereabouts in recent years, the distance away from the main stream of this stanniferous material being somewhat surprising.

On *Fossickers' Gully* no work has been done for many years past. The tinstone is black, with a noticeable absence of black sand. No gemstones were found here. The sinking is shallow. This gully was never rich in tinstone.

The famous *Brisbane Claim*, one of the richest alluvial tin claims ever worked in the world, has been dredged and re-dredged in past years, but at the time of my visit was quite idle. However, there are rumours indicating a probable re-working of portions at least of this one-time enormously rich deposit.

On portion 328 occur numerous aplitic granite dykes intruding the "Stanthorpe" granite; these veins pass into pure quartz at times.

On portion 327, close to the old Little Ruby Tin Mine, (alluvial), a vein of crystallised white quartz in coarse acid granite was opened by Mr. Henry Collins many years ago. It has been exposed on the right bank of the creek by a shallow trench along the cleavage of the granite. Strike of reef, north-east and south-west; underlays to the east. The width of this vein averages 5 in. It carries here wolfram and molybdenite splashes, these minerals being disposed along the outer edges of the quartz seam. The country rock has been partly greisenised, though it would not be strictly accurate to term it a greisen. On the left bank of the creek, where this vein has been opened by a hole on a ridge, tinstone shows sparsely through the quartz. The molybdenite is mostly confined to the outer edge of the vein as in the previous case. A little copper pyrites was met with in the quartz at the surface. On the southern fall of the ridge into Thirteen-mile Creek small quantities of well-crystallised tin were obtained from shallow surface trenches, and it is quite possible has been derived from the denudation of the south-western extension of this quartz vein.

QUART-POT CREEK.

On portion 368, parish of Stanthorpe, are several small dykes of aplite, from which radiate quartz veins, one veinlet of half an inch in width being readily traceable for several chains in an easterly direction. This vein shows the relationship existing between the intrusive aplites and the well-known quartz

" blows" seen at times in granite. An extensive high bar of coarse granite occurs here. Below this bar and to its junction with the Broadwater River the stream traverses a narrow sandy flat. The presence of small rounded pegmatite intrusives has led to the formation of numerous potholes on the rock surface, due in the first instance to the relatively rapid decay of the large orthoclase felspars in the pegmatites. Near portion 349 is a large supply dam, at which is washed the tin-bearing material carted from the neighbouring claims. Along the left bank of the creek, near the north-east corner of portion 317, parish of Broadwater, a considerable amount of alluvial tin has been worked, the overburden comprising grey clay and a little coarse sand; depth of overburden, approximately, 10 ft. This deposit extends to a few chains below the sharp bend in the creek in portion 317, and has been laid down as a result of the hard high bar of " Stanthorpe" granite crossing the creek bed at the bend in question. Immediately below this bar a fair amount of shallow " surfacing" was done in the early days of the field; but the rocky nature of the area militates greatly against operations such as dredging. The alluvial has been worked to a greater or less extent on portions 348, 344, and 345 (opposite Bald Rock). At the junction of a small gully on portion 346 a dam has been made to store water for washing the stanniferous material in the vicinity. Adjoining this small dam, on the downstream side, is a larger dam at the junction of a gully on portion 350. The right hand bank of this alluvium (which has been worked intermittently since 1872) is shallow " surfacing" in grey clay. Higher up the gully the ground becomes deeper, and consists of coarse quartz and felspar sand cemented by clay. Mining of a desultory nature is in progress here, carried on by about ten prospectors in all, as opportunity is afforded by rainfall to treat the washdirt. On *E. Taylor's claim,* near the head of the workings, the total depth of sinking is about 30 ft. The bottom level of washdirt proved comparatively barren, but at a depth of 15 ft. below the surface occurs a seam a few inches thick of rich washdirt carrying fine-grained black tin. Judging by the risks that have apparently been taken recently to remove portions of old " headings," some of this area must have been fairly rich. The ground is hard to remove in places, and recourse is had to blasting to bring down the overburden. The origin of this " false bottom" here is discussed in this bulletin under the heading of " *Recent* Deposits." Other claims being worked at the time of my examination in April, 1913, were: *Connor and Smart's, Ross and party's,*

and *Slattery's*. These workings are on what is known locally under the name of the *Britannia Gully*. Much black sand, with an occasional topaz and sapphire, are met with during sluicing. The alluvial tin appears to pass out on to hard rock at the top of the gully. The source of the tinstone is somewhat problematical, but has probably been derived from the granite itself rather than from any lodes. Further patches of "cement" occur along the left bank of the gully, resulting in this instance from the cementation of granitic detrital material by kaolin from the felspars in the coarse granite.

For some distance downstream below the junction of Britannia Gully is a wide bar of hard rocks along which little or no tin has been mined. A hard bar, with tin in the "surfacing" through it, also occurs in the centre of the alluvial at the junction of Britannia Gully. Many years ago an engine was installed on the right bank of the gully at its junction with Quart-pot Creek, for the purpose of pumping water up to the Britannia Gully workings for sluicing the surface deposits there.

Above the township of Stanthorpe, along the frontage of portions 282 and 283, parish of Folkestone, occurs a large area of alluvial material (mostly loose sand). Above this spot small patches of good tin have been obtained from time to time from among the loose boulders forming the bar.

On the upper portion of this stream, at Kyoomba, a moderate amount of surface sluicing has been done on the right bank towards its junction with Sugarloaf Creek. Much kaolinic material and "cement" occurs with the tinstone in this area. The gravel is mainly waterworn quartz of medium size.

A considerable amount of work has been done during late years on portion 633, parish of Folkestone, as also along portion 428, both areas being on *Kettle Swamp Creek*, a right bank tributary of Quart-pot Creek.

FOUR-MILE CREEK.

Rover Tin Mines.—This portable dredge, better known locally as the Four-mile Creek plant, from the name of the stream along which it is working, is owned by Mr. Lawrence Nevin. The late Mr. A. G. Hamilton was manager at the time of my inspection in July last. The ground included within the area held comprises portions 273, 274, 239, 276, 308, &c., parish of Folkestone, about 4 miles north-east of Stanthorpe.

A large supply dam (capacity 55,000,000 gallons) near the head of the creek, on portions 273 and 274, affords ample protection against loss of sluicing time during spells of dry weather. The Railway Department has an arrangement with the owners enabling them to draw supplies for their locomotive when required.

The dredging plant in use here comprises the following:—two 20-h.p. "Robey" portable engines, one 10-in. "Gaukrodger" gravel pump, and one 10-in. "Sands" nozzle pump. The sluice boxes have a total length of 120 ft., the width and depth being 8 ft. and 2 ft. respectively. A dynamo is installed to work an electric-light plant, running at about 110 volts; power for the dynamo being furnished by a 4-h.p. vertical "Robey." At the time I examined this claim, the management were using coal from Tannymorel Colliery, at a total cost of 18s. 6d. per ton, delivered to the dredge. The fuel consumption then averaged 30 tons per week. Prior to that time firewood, costing 11s. per cord, had been used, and the use of coal was much in the nature of an experiment to try and save as much as possible the rather excessive cost of carting the much greater quantity of firewood necessary to provide the same steam power as the lesser weight and volume of coal. It was considered, also, that less trouble and labour would be found in the matter of firing with the coal than with firewood.

This dredging claim was first worked as such by Messrs. Gibbs, Bright, and Company, who styled it the Rover Tin Mine. Operations were commenced by them some eight years ago, and continued for about a couple of years. The present owners started on the 12th June, 1910, actual sluicing being entered upon during the following month. They have carried on dredging nearly continuously since that time, during which the following returns were furnished:—

	Cubic yards.			Tin. Tons	cwt.	qr.	lb.	Value.
1910—July to Dec.,	57,320	material treated for a yield of		21	11	0	0	£1,827
1911—Jan. to Dec.,	123,297	,,	,,	39	10	0	0	4,685
1912—Jan. to Dec.,	112,700	,,	,,	36	3	2	21	4,854
1913—Jan. to March,	25,000	,,	,,	12	10	0	0	1,707
April to June,	21,000	,,	,,	6	11	3	0	900
Total ...	339,317	,,	,,	116	6	1	21	£13,973

It is considered that this plant has at the least two years' work ahead of it, and future prospecting may extend the life considerably. The alluvial along this creek has never been phenomenally rich, and is characterised by being very patchy as regards tin values. The stream tin is of high purity, estimated

by the manager at 75 per cent. It is mostly very fine-grained and brownish in colour. The ground being dredged has practically all been mined in the past.

A little yellowish and gray fine monazite sand accompanies the tinstone; very occasionally topaz, sapphires, fourteen small straw-coloured diamonds, and half an ounce of gold (very thin and waterworn) have been recovered during sluicing operations. Abundant specks of wolfram and ilmenite and gem sand (mainly tiny zircons) are also present in the washdirt.

The bottom is composed of the fine-grained ("Sandy") granite, which is here rather hard, and with a fairly even floor. Numerous pegmatite veins traverse the bedrock. Associated with these veins are later veinlets of quartz having a general strike of 50 degrees, which corresponds with the dominant cleavage lines hereabouts; the veinlets dip south. Patches of a semi-graphic granite structure are noticeable throughout the rock mass.

The accompanying section (Fig. No. 4) has been compiled from the results obtained by a series of boreholes across the alluvial deposits on this creek in order to show the nature, thickness, &c., of the materials dredged. The very uneven upper surface is accounted for by the fact that the section line passes over old worked ground.

The owners are planting an extensive orchard on portion of the freehold land comprised within the area held.

SPRING CREEK.

The Horseshoe Tin Sluicing Company, Limited.—This company's portable dredge—better known locally as the Spring Creek dredge—is operating on Dredging Claim No. 27, parish of Marsh, six miles west-south-west of Stanthorpe, on Spring Creek and tributaries, immediately below the Pikedale Road.

Compared to most of the other dredges in the district, this is a small plant, comprising two 16-h.p. portable engines, nozzle, and gravel pumps, &c.

The overburden consists mainly of 12 to 15 ft. of granite-derived clay and sand resting on a fairly even soft granite bottom.

This being one of the most recently erected dredges (sluicing having commenced in May of the present year, 1913), it has been thought desirable to afford an idea of the methods now in vogue

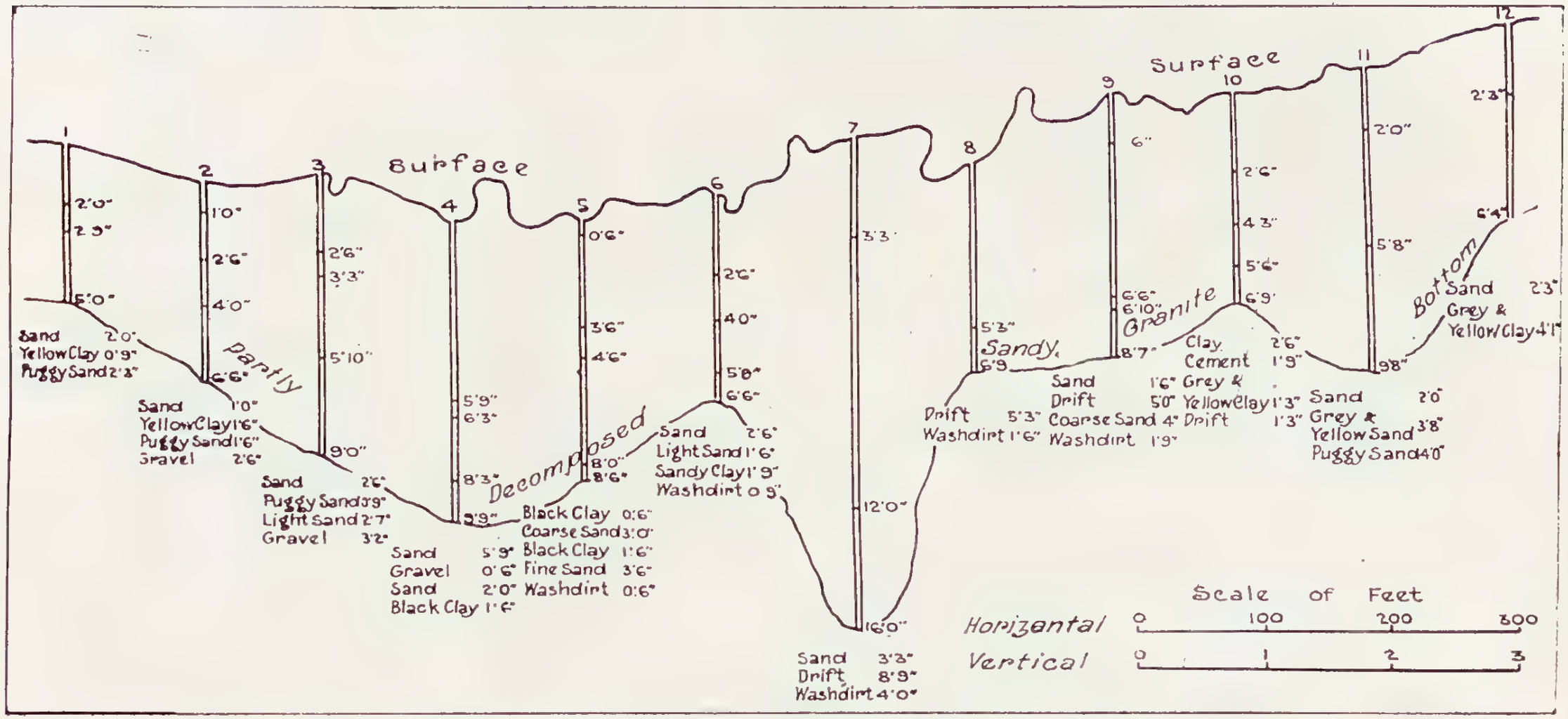

FIG. 4.—Section of the Stanniferous Alluvials along Four-mile Creek, Stanthorpe, as indicated by boreholes.

in this district. For this purpose several photographs have been obtained to show the different phases of the industry. The first of these views (Plate No. 11) shows the undermining of the overburden by the high pressure of water delivered from the nozzle. This plate gives a good idea of the general arrangement of the

PLATE 11.—HORSESHOE TIN-SLUICING COMPANY'S PORTABLE PLANT, SPRING CREEK.
Showing the Overburden being Undermined by the Nozzle.

plant used in portable dredges, the material being broken down by the nozzle and sluiced into the sump hole, from which it is pumped up into the sluice boxes.

The next photograph (Plate 12) gives us a near view of the two portable engines, which supply the requisite power for the nozzle and gravel pumps; the gravel pump is seen on the left-hand side of the picture. As will be seen, this plant is belt-driven; in the case of several other plants the power is transmitted by ropes, and much controversy wages around this

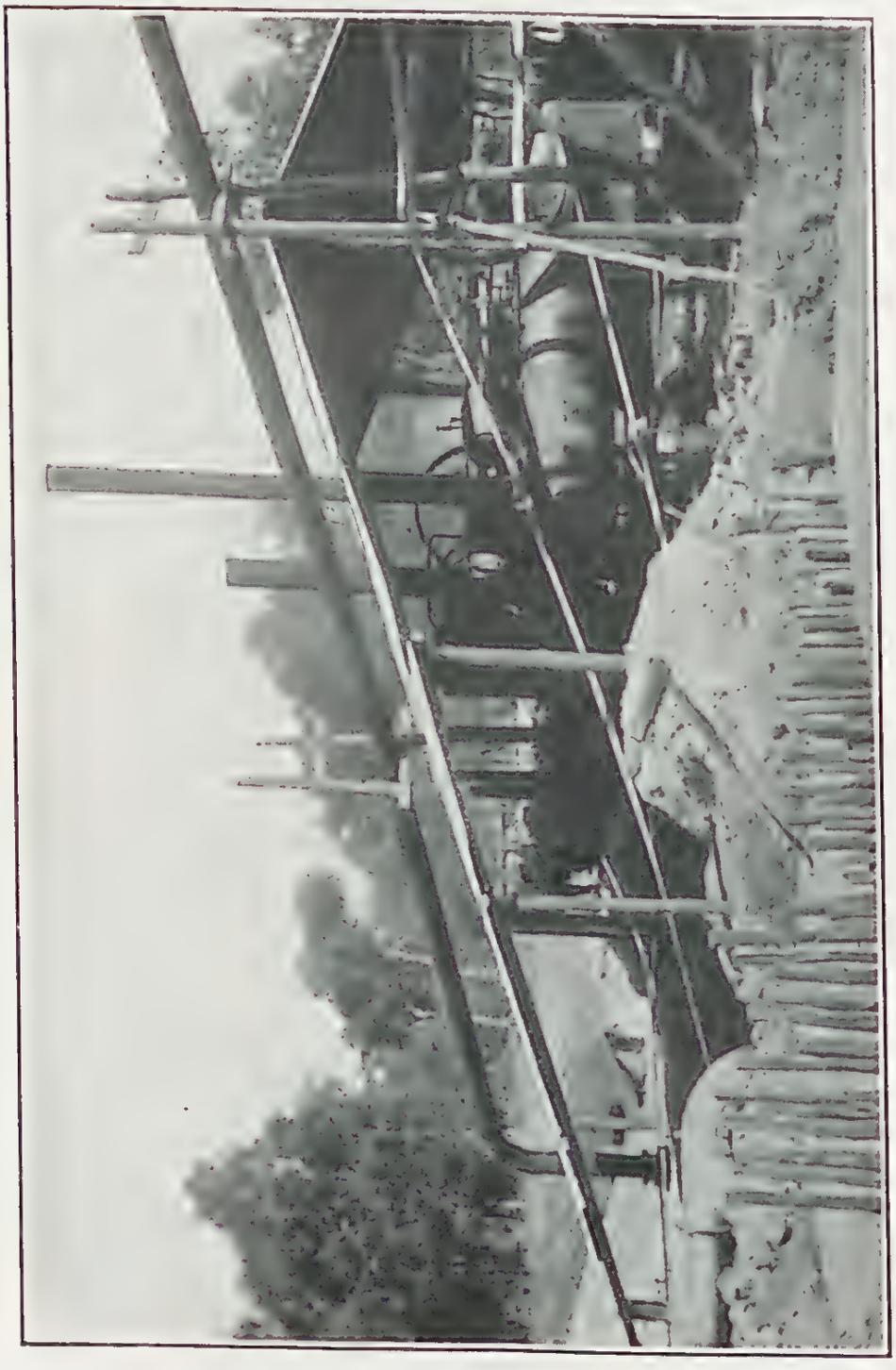

PLATE 12.—HORSESHOE COMPANY'S PLANT
Showing the Engines and Pump.

subject; the consensus of opinion in the various dredging centres seen by the Writer in New South Wales appears to be that rope-driving is best suited to barge dredges and belt-driving for portables.

Plate No. 13 shows the cheap but very effective method of building dams by utilising the tailings from the sluice boxes. the outside retaining wall being constructed of bushes against which the dredged material piles itself into a firmly-set body of

Plate 13.—Horseshoe Tin Company's Dredge.
Showing the Method of Constructing a Tailings Dam with Bushes.

clay, sand, and gravel. The construction of these settling dams enables the water to be used over and over again—a vital factor in dredging operations as a rule.

There is approximately four years' work ahead of this plant, it being the intention of the company to also work along the main stream channel, the present site being in reality in Pikedale Gully.

Below this claim the channel of Spring Creek becomes rock bound. The upper portion of Dredging Claim No. 34 consists of a wide bar of coarse acid granite, amongst which rocky outcrop some shallow "surfacing" has been worked. The lower portion of the creek channel on this claim (34) opens out into a limited flat, up the centre of which a moderate amount has been done in the past. The alluvial material is here largely dark clay resting on coarse granite sand and a relatively small quantity of medium to fine gravel consisting of waterworn quartz. On portion 89v and 40v a small amount of mining has been done along the creek.

BLUE MOUNTAIN GULLY.

Stanthorpe Tin, Limited.—This company's plant (Mr. J. B. Ferris, Manager), which at the time of my visit was operating on portions 618 and 631, parish of Folkestone, some 2½ miles north-east of Stanthorpe, is known locally under the name of the Blue Mountain Dredge, from the fact that it is operating on the alluvial along Blue Mountain Gully, near Blue Mountain, adjoining the western side of the road from Stanthorpe to Amosfield, *viâ* Ruby Creek. A strip of stanniferous alluvial about 3 miles in length, stretching from near Kettle Swamp Creek to the State border, is owned by this syndicate.

The plant is a portable one, made up as follows:—Two 20-h.p. Robey and Marshall portable engines; one 10-in. gravel pump; one 10-in. nozzle pump; capacity estimated at 40 cubic yards per hour; pressure, 35 lb. per square inch at the nozzle; 120 ft. of sluice boxes having a width of 8 ft. and a depth increasing from 1 ft. 9 in. at the tail to 2 ft. 3 in. at the head; "fall" allowed to the boxes, half an inch per foot.

The total cost of the plant and the necessary preparations, ready to start work, was roughly about £5,000.

From the sump-hole to the pump the material is elevated 15 ft. in (vertical) height; from the pump to the delivery at the head of the sluice box an additional 35 ft. of lift is required.

Firewood consumption amounts to 4 cords per shift of eight hours; stringybark is here considered to give the most satisfactory results. The cost of the firewood is 11s. per ton for cutting and delivery (including 1s. 6d. per ton royalty for permission to obtain the wood from privately owned land).

It has been found that the use of two nozzles is a distinct gain, as that arrangement enables sluicing to be carried on

uninterruptedly during the time required to shift one or other of the nozzles to different portions of the "paddock" or wherever else it may be required.

Owing to an abundant supply of water being available in June, as a result of the splendid rains experienced this year, the management had, at the time of my visit, an ample quantity to permit of two shifts being run. The number of men employed was usually about 18 all told.

Operations commenced on 1st April of the present year (1913), and up to the middle of June some 1½ acres had been dredged, for a return of 2 tons 14 cwt. 17 lb. of tinstone, valued at £1,434, the number of cubic yards handled being estimated to be 16,700.

The alluvial material being treated here consists largely of creek sand, which presents no difficulties whatever as a dredging proposition. Much grey and black clay occurs in places, and is productive of a loss of tin in the boxes unless carefully watched, as it rolls down the sluice and gathers around itself the already washed tinstone. The average depth of the overburden is 10 ft. In places, especially along those portions of the "bottom" not worked by the tin miners in the early days of the field, a thickness of 1 ft. of stony wash—mostly of angular quartz and "sandy" granite pebbles—overlies the bedrock. The "bottom" consists of a fairly even floored fine-grained acid granite. An absence of any appreciable quantity of black sand accompanying the tinstone is here, as elsewhere in the case of streams draining the "sandy" granite country, a feature characteristic of the alluvial deposit. The tinstone comprises both ruby and black coarse-grained material of high metallic contents, 75·65 per cent. being a recent assay in bulk. No gemstones have been recorded from these workings.

Although the average width of the dredging ground runs from 7 to 10 chains, there are hard rocky narrow portions of the stream channel that it will probably be found hardly worth while to dredge except in certain favoured localities from which the material could be sluiced towards the plant in the first instance.

The accompanying photograph (Plate No. 14) shows (*a*) the construction of the frames to support the sluice boxes, and (*b*) the height to which the material is elevated between the pump and

the delivery at the head of the boxes. Note the banking up of the tailings towards the end of the box supports by means of a dam constructed of rows of bushes laid horizontally.

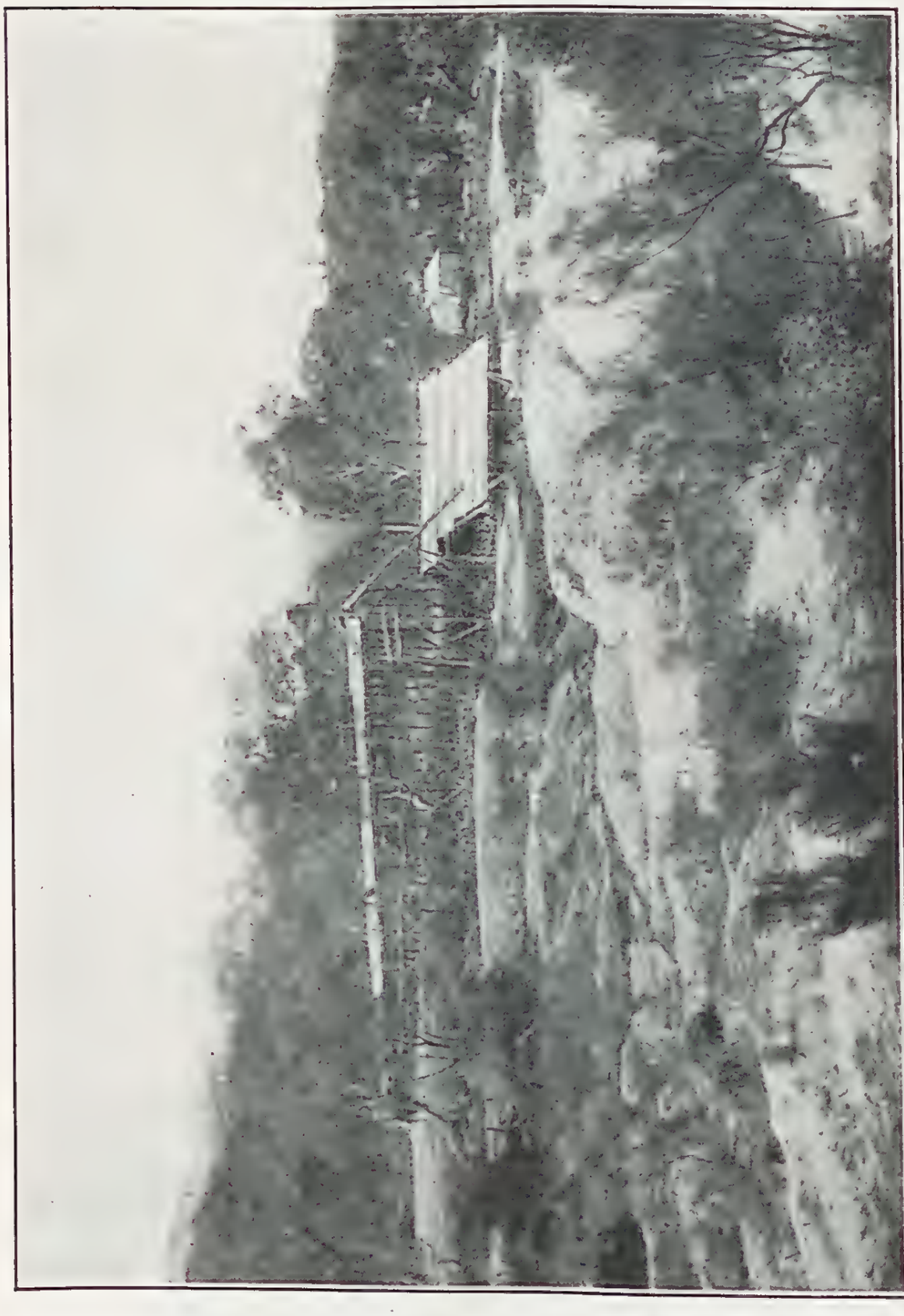

PLATE 14.—STANTHORPE TIN, LIMITED.
Portable Dredge, Blue Mountain Gully.

The next view (Plate 15) gives a good idea of the general lay out of a dredging plant (portable variety); it illustrates the breaking down of material by the nozzle controlled by the

operator both as regards the direction and elevation of the water jet. In the foreground a large cask, secured by a strong chain, is seen swimming around in the water at the sump-hole, its

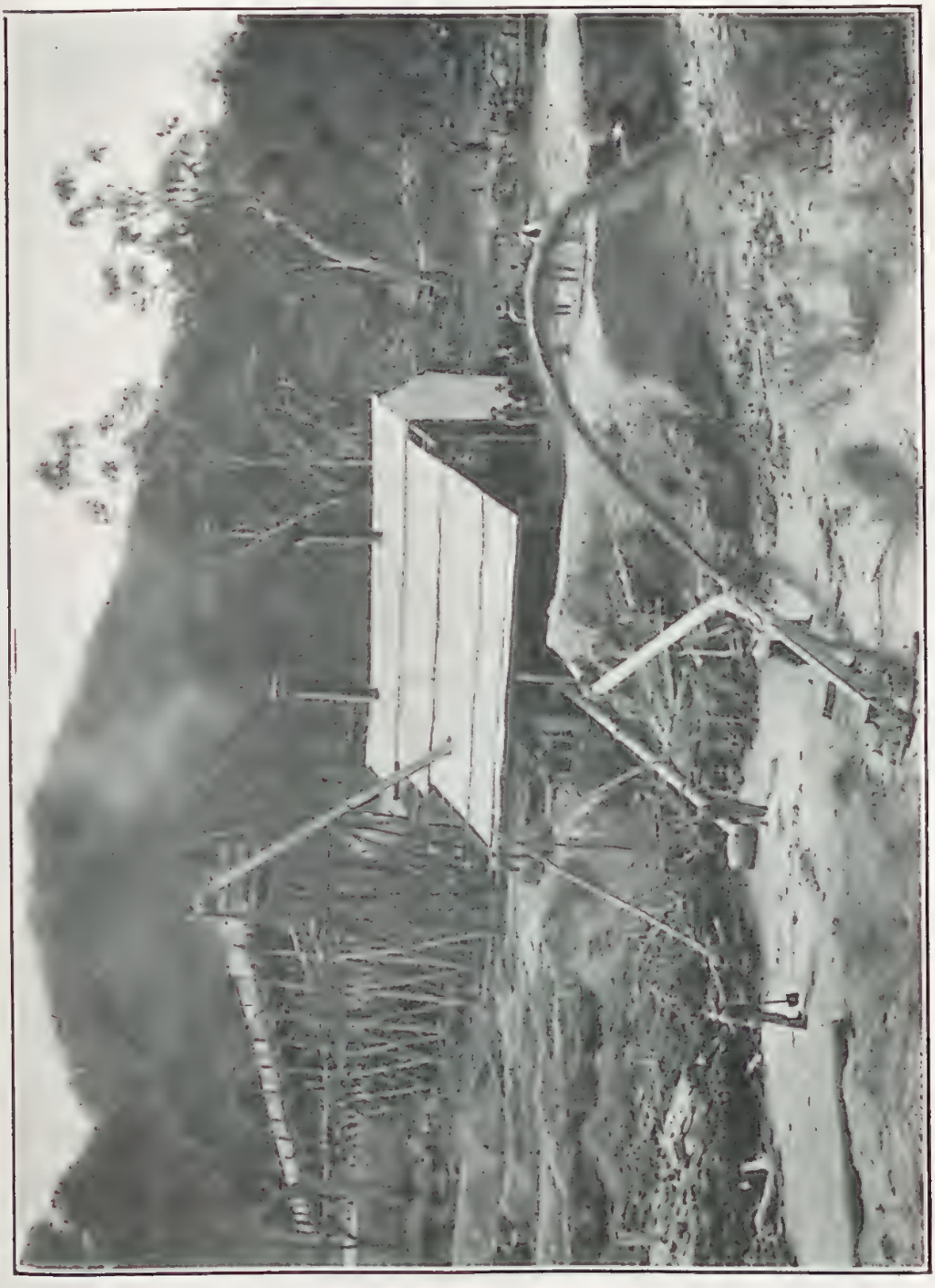

PLATE 15.—STANTHORPE TIN, LIMITED.
Showing the Nozzle at Work, and also the Method of Pumping the Material up into the Sluice Boxes.

presence here being for the purpose of breaking up the whirlpools produced by the powerful suction around the mouth of the intake pipe. The shear-legs are required to enable the heavy

pipe being raised or lowered as required. The high hill seen in the background is the well-known Blue Mountain, which forms such a prominent feature of the landscape to the north-east of the township.

Our next picture (Plate 16) gives a near view of the nozzle seen in Plate 15. This picture illustrates clearly the method

PLATE 16.—DREDGING CLAIM OF STANTHORPE TIN LIMITED, BLUE MOUNTAIN GULLY, STANTHORPE DISTRICT. [*Photo. L. Jolson.*

Near View of Nozzle, showing how the Direction of the Water is Controlled.

of controlling both the direction of the powerful stream from the nozzle and also its elevation to any required angle. Note the decrease in the diameter of the pipe from the flexible joint

to the actual nozzle. The road in the middle distance, immediately beyond the dredging ground, is that from Stanthorpe to Amosfield.

Just prior to my leaving Stanthorpe I learned that the management had an intention of removing the plant to a site some distance downstream (nearer the town). This has since been carried into effect.

TEN-MILE ROCKS, SWAMP CREEK.

Toowoomba Tin Dredging Company, No Liability.—This company is operating at Dalcouth Flat, on dredging claim 4, parish of Folkestone, about 4 miles east of Stanthorpe; Ten-mile Rocks Swamp Creek.

At the time of my visit no work was in progress, suspension of the labour conditions having been granted. On the occasion of a subsequent visit (in July) sluice boxes were being erected preparatory to a renewal of operations by a party of tributors.*†

The plant here is one of Messrs. Thompson and Company's barges, identical with that at Sugarloaf.

The overburden consists of 14 ft. of grey sandy clay resting upon a usually hard and uneven "Sandy" granite bottom strewn with large boulders. The washdirt averages about 1 ft. in thickness, and consists mostly of gravel, which is in places very puggy. At times, however, the tinstone is found in a layer of sandy drift lying along the sides of the channel. The tin is dark coloured and is remarkably free from both black sand and gemstones, the absence of the former common associate being due to the fact that the stream traverses the fine-grained acid granite and receives no material from the "Stanthorpe" granite.

As will be seen by a glance at the following table of statistics, the last few months' operations of this plant have not been attended with satisfactory results. A considerable area of stanniferous alluvial still awaits treatment, but it is in no wise certain that it carries sufficiently high values to warrant exploitation by present-day methods of dredging.

This dredge was one of the first plants on the field:—

			Tons	cwt.	qr.	lb.		
1910—August to December,	74.676 tons	treated for	22	1	2	0	worth	£1,797
1911—January to December,	69,000	,, ,,	18	3	0	0	,,	2,237
1912—January to December,	100,000	,, ,,	23	9	0	21	,,	3,159
1913—January to March,	5,000	,, ,,	0	19	1	0	,,	130
April to June,	3,500	,, ,,	0	16	3	0	,,	125
Total	252,176	,, ,,	65	9	2	21	,,	£7,448

*The "fall" allowed to the boxes here is 3 ft. 10 in. per 100 ft.

†The "Rees Hughes" patent tin-treating plant has been erected here (1914).

A Mr. Farrar, well known in the Stanthorpe tin-mining industry, was, at the time of my examination, making arrangements preparatory to commencing sluicing operations with a portable engine along this same creek below the Dalcouth workings.

The alluvial material consists mainly of sand and yellow clay, averaging 8 to 10 ft. in thickness and resting upon a very decomposed coarse acid granite bottom, traversed by aplite dykes. A fair amount of black sand accompanies the tinstone on the Chinaman's Flat portion of the area dredged, but this material is practically absent from Lode Creek above its junction with the flat named. This feature is a natural result of the fact that the former receives detrital material from the "Stanthorpe" granite, whilst the latter stream is the repository of alluvials resulting from the denudation of the "Sandy" granite.

Sluicing operations commenced in May of the year 1911, since which date the appended yields of stream tin have been recorded:—

			Tons	cwt.	qr.	lb.		
1911—May to December,	87,000 c. yds. treated for		17	17	0	0	worth	£2,208
1912—January to December,	77,260	,, ,, ,,	31	13	1	18	,,	4,455
1913—January to March,	21,000	,, ,, ,,	10	12	0	0	,,	1,520
April to June,	25,000	,, ,, ,,	9	2	0	0	,,	1,325
Total	210,260	,, ,, ,,	69	4	1	18	,,	£9,508

In the area along the border range, known locally as *Lode Hill*, numerous greisenised quartz veins, with tin and wolfram in acid granite, have been worked in past years, but the results obtained have been far from encouraging. As these occurrences have been fully described by previous observers, it is unnecessary to do more than draw attention to their existence. Two recent attempts have been made to work some of these metalliferous veins, one, on the eastern boundary of portion 333, parish of Folkestone, being a shallow costeen across a greisenised vein in granite, carrying sparsely-distributed crystals of tinstone of small size. Strike, east-north-east; dip, vertical. The gangue of the tinstone is bluish white quartz with white mica (muscovite), accompanied with small crystals of quartz in vugs. The application of the term "greisen" to this rock is, in my opinion, incorrect, "micaceous quartz" being a much more accurate term.*

On M.H. 277, parish of Folkestone, five small veins of micaceous quartz similar to the above were revealed by a trench

* *True* greisen occurs, however, in abundance at the Lord Nolan Mine, Ballandean (*vide* page 110).

on the summit of the ridge. Odd specks only of tin and wolfram are now visible. Country rock, "Stanthorpe" granite, near its junction with "Sandy" granite. Strike of the veins, north-east; dip, vertical. The "formation" in which these veins occur is readily traceable for a distance along the ridge.

LODE CREEK.

Red Hill Tin Sluicing Company.—This company's plant (Mr. F. Kelly, Manager) was working on portion 352, parish of Folkestone, at the time of my visit in July, 1913. The syndicate also owns portions 351, 347, 381, 338, and 337. Location: Red Hill, about 8 miles due east of Stanthorpe, adjoining the New South Wales border, at the head of Lode Creek.

The machinery, &c. (which is said to have cost about £6,000 ready to start work), is comprised as follows:—One 20-h.p. "Ransome, Sims, and Jeffries" portable engine, which works a 10-in. gravel pump ("Thompson's") and one 30-h.p. similar engine working a 12-in. nozzle pump. The plant is rope-driven. The sluice boxes have a total length of 100 ft., and have the following additional dimensions:—Width 10 ft., depth 2 ft. An electric-light plant has been installed.

Water is pumped for a distance of 1½ miles from the Lode Creek dam, power for this elevation (250 ft. vertical) being supplied by a 12-h.p. portable driving a 6-in. "Gardner" high-pressure pump. Firewood costs approximately 8s. a cord, stringybark being the most favoured for this purpose.

The capacity of the plant in full swing is estimated at about 120 cubic yards of material per hour, but at the time of my examination a yardage of under 50 was being recorded. Two shifts per day are usually the rule. Twelve men were being employed in July, but the full complement is stated by the manager to be fifteen.

Speaking generally, the alluvial may be said to be very shallow here, averaging about 4 ft., but the manager informs me that some of the ground runs to as much as 12 ft. in depth. The overburden consists of both loose and compacted sand (from the "Sandy" granite), with a small admixture of reddish and yellow clay. Small quantities of washdirt (missed in the early days of tin-mining) are sometimes met with along the main gutters. As might have been expected from its situation in a "Sandy" granite area, no black sand is met with, nor have gemstones been found in any noticeable quantity. The tinstone

is medium to fine in grain, and of high purity, much of the ruby variety occurring with the usual black tin. The "bottom" is fairly even, and is mostly decomposed. It is composed of the fine-grained acid granite.

Sluicing operations have shown that insignificant quantities of wolfram (from the numerous small wolfram and tin shoots in greisenised granite at the head of the creek) are scattered irregularly through the overburden and along the bottom.

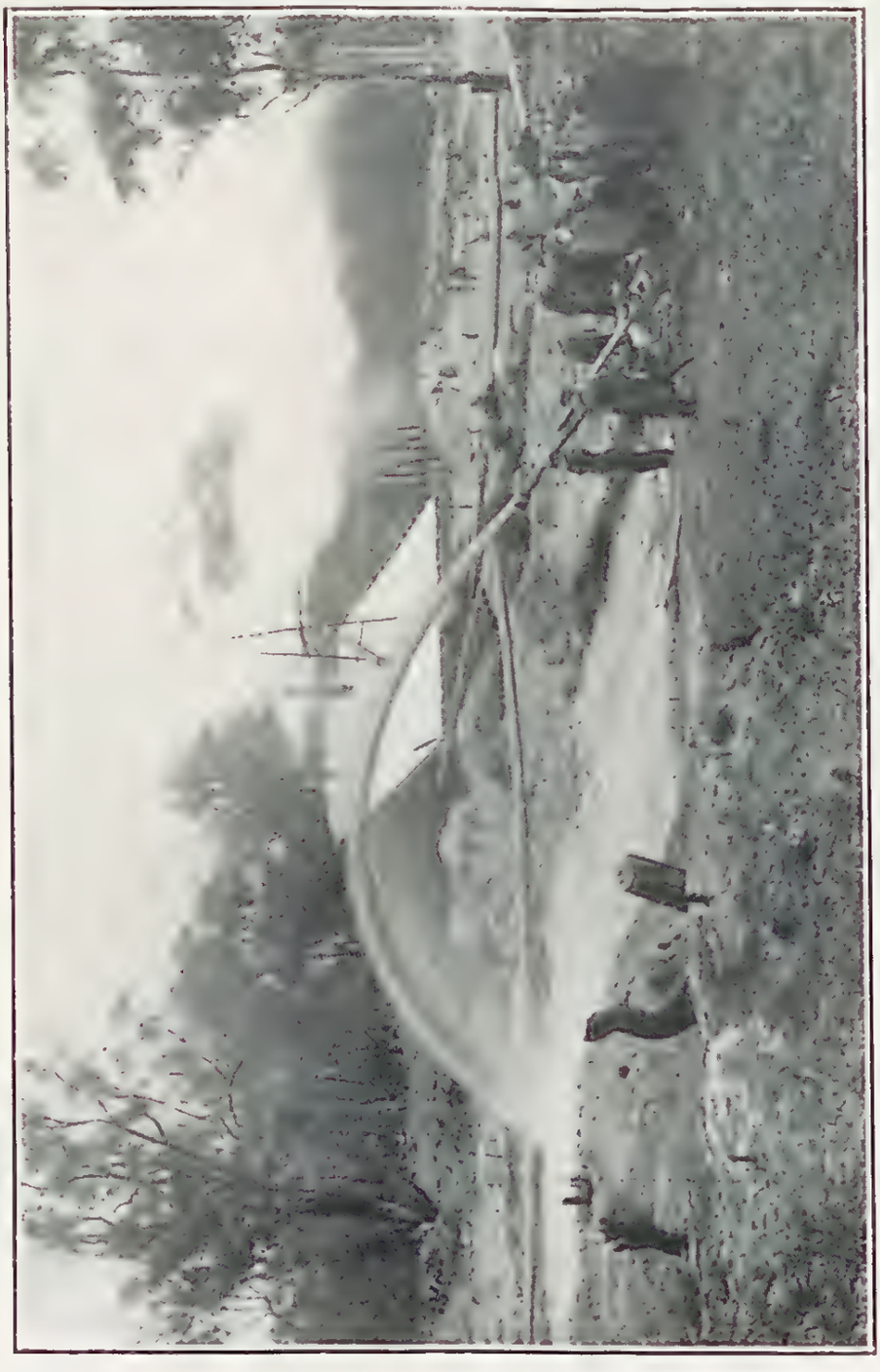

PLATE 17.—RED HILL TIN-DREDGING COMPANY'S PORTABLE PLANT. [*Photo., L. Jobson.*
Showing nozzle operating on shallow ground.

The tinstone occurs throughout the overburden; indeed in places it was often more abundant here on the actual surface when found than in the washdirt along the bottom.

Sluicing operations were commenced in May of the present year (1913), and from then to the 30th June 11,000 tons of material were treated for a yield of 6 tons of tinstone, valued at £880.

A view of this plant, showing the shallow depth of the ground over most of the dredgeable area, is given in Plate 17.

Lode Creek Tin Dredging Company, No Liability.—This plant, one of the few barge-dredges, was, in June, working on portion 420, parish of Folkestone, at the junction of Chinaman's Flat and Lode Creek, a tributary of Sugarloaf Creek. It was being managed by Mr. F. Kelly, in conjunction with the Red Hill dredging plant. The plant is similar in every respect to that operating at Sugarloaf (for which see description), with the exception that it does not carry a surface condenser. The water required is pumped from Sugarloaf Creek, about 5,000 gallons per hour being delivered, but it was the intention of the owners to instal a 10-h.p. portable engine and a 6-in. centrifugal pump to increase the supply. The sluice boxes are 8 ft. in width, and tapering from 3 ft. at the head to 18 in. at the tail. The plant is stated to have cost £4,000 when ready to run.

BROADWATER RIVER.

In order to gain a knowledge of the conditions obtaining along this stream, a traverse was made from the south side of the Stanthorpe-Pikedale road crossing, near the Broadwater School, to the junction with Quart-pot Creek. The following notes were made by me in April of the present year (1913) :—

Near the road the Broadwater River is a rock-bound ti-tree covered stream, with a little "surfacing" along the left bank. The bottom hereabouts consists of the coarse acid granite intruded by occasional small dykes of aplite. Some more or less isolated patches of good tinstone were obtained from between the boulders along either bank in this locality. Where any true alluvium is present it appears to be very shallow. On the Water Reserve near portion 747 is a large lagoon, along which but a very insignificant amount of work has ever been done. This lagoon is a typical reed-bordered stretch of water covered with water-lillies. Below this water-hole the flats open out, and have here been worked to a considerable extent. On these flats the overburden comprises coarse angular granite sand composed of quartz and felspar dèbris. In this neighbourhood the soil immediately adjoining the stream flats is now being successfully cultivated for maize, melons, cabbages, tomatoes, and fruit trees.

F. Eberhardt's claim, on his private land on the left bank of the stream, was commenced in the early part of the year. The depth of ground is from 12 to 14 ft., the overburden being essentially coarse granite sand with a small admixture of grey clay. A noticeable amount of water was met with, which has given the prospectors some trouble seeing that mining operations are being carried on by hand labour. The water has not only to be pumped out of the "paddock" each morning by means of a "spear-pump," but removal of the water brings about the caving-in of the sides owing to the presence of loose sandy drift near the bottom. The washdirt consists of coarse grey sand with a fair sprinkling of subangular and waterworn quartz pebbles and occasionally topaz. The tinstone is rather fine-grained, well waterworn, and consists mostly of black tin with some ruby and a little resin tin. Sapphires have been seen at times. There is a noticeable absence of black sand in the washdirt hereabouts. Several boreholes appear to indicate a considerable extension of stanniferous material on this property adjacent to the present workings. At the time of my visit the main seam of tin-bearing "wash" was from one to ten inches in thickness. Very little or no tin occurs through the overburden, though a thin rich seam was found some 15 in. above the washdirt. The "bottom" is here of soft granite with a somewhat uneven surface. The erection of a small plant on this property appears to be warranted providing that boring proves the existence of a sufficient area of payable stanniferous alluvial. There is always an abundance of readily available water from the numerous lagoons along the stream facing these workings. At the time of my visit in April, 1913, the prospects were distinctly encouraging.

An extensive and deep lagoon succeeds this flat immediately below Eberhardt's claim. Along the southern bank opposite this lagoon the alluvial deposits extend for some distance southerly. At the lower end of the lagoon are several well-defined bars of coarse granite crossing the stream bed. Opposite the south-west corner of portion 4, parish of Stanthorpe, a small flat opens out below the bar, but appears to carry insufficient quantities of tinstone to repay working. Near the south-west corner of the next block is a hard and extensive bar of coarse granite, on which the action of flood waters producing elongated potholes on the hard surface is a notable feature. The lagoons appear to have been developed in part by flood conditions, when the rush of waters over the hard rocky bars has gouged out deep holes in the relatively softer rock

immediately below the bars down stream. At times small outcrops of aplite are to be seen intruding the granite along this portion of the channel, the quartz blebs in the aplites standing out in bas-relief above the general mass of the rock by reason of the greater resistance they offer to the agencies of sub-aerial denudation. On Reserve 82 is a well-marked nearly horizontal seam of aplite, striking north 50° west across the here rocky bed of the stream. Several small intrusive veins of felsitic material radiate out from the main mass, averaging 4 ft. in width. On the right bank of the river, on portion 6, parish of Marsh, a limited amount of "surfacing" has been worked, the water having been brought by a long head race from higher upstream on the rocky bars.

Higher upstream (above the road crossing referred to) several areas of extensive alluvial occur along the river. One to which a fair amount of attention has of late been directed, as a possible dredging proposition, is that owned by Mr. W. T. Boatfield. *Boatfield's claim* is on portions 626, 625, 624, and 670. Towards the centre of portion 624 along the stream the ground averages 15 ft. in depth. A top "cement" hereabouts carried fine well waterworn wash dirt. A second layer of stanniferous wash was also found lower down. The tinstone is medium to fine-grained, ruby to black in colour, and occurs mainly in a wash, up to 2 ft. in thickness, composed of coarse granite sand with a little clay. Black sand is practically absent. The amount of water encountered below the level of the creek-bed has hitherto been a great bar to working this deposit. The bottom, wherever seen, has been of decomposed coarse granite with an even surface. Topaz and sapphire (especially the former) occur through the wash on the bottom. Tinstone in small quantities has been found in places on the left bank from the surface right through the overburden. Towards the south-east corner of portion 624 tin was also found through the overburden. Opposite the south-west corner of portion 626 the flat becomes very wide, and does not appear to have ever been much worked here. The depth of the alluvial, where bored across the flat on portion 605, is said to have averaged 14 ft., the material consisting partly of black mud with some loose drift sand. A considerable amount of apparently virgin ground occurs along the stream channel owing probably to the excessive quantity of water present rendering hand work out of the question. At the junction of Reeves' Gully the alluvial widens out again. The old company (Brisbane Broadwater Tin Mining Company)

started their operations a few chains downstream from the confluence, the tin values then obtained being highly remunerative.

Above portion 670B the stream runs through a gorge for a considerable distance. The major portion of the main alluvial flat on this claim would be treatable by a barge dredge, but the upstream section of the area in this claim would very probably necessitate the use of a portable plant. A little alluvial has been worked along Reeve's Gully. An area of flat ground on the eastern half of portion 624, where "surface" tin (not payable by hand work) with odd wash stones occur. There is an abundance of good firewood near this claim, and an ample supply of water for boiler and sluicing requirements. The dredgeable material along the main stream channel averages about 6 chains in width and is upwards of four-fifths of a mile in length. The richest portion worked so far is said to be that opposite Mr. Boatfield's residence. Several large water-races and dams (with sod walls), made by the former company, would probably be of service in any future mining operations here. A hard bar of granite crosses the stream immediately below the old (now ruined) dam wall. At this spot a large quantity of tin was obtained many years ago.

Below Boatfield's claim is an extensive flat, similar to that just described, the area of which warrants careful prospecting by boreholes as a possible future dredging site. This flat bears the local name of Sheehan's.*

SEVERN RIVER.

Beverley Dredge, on the Severn River, from Beverley to Glen Aplin and close to the railway line (J. S. Beatty, manager; C. Lee, representative).

This is the most recent of the dredging claims started in the district. The owners have purchased a considerable area of ground, mostly on the left bank of the Severn River, and intend working the stream channel for tin. At present they have one portable plant in operation, comprising the following:—Two 20-h.p. "Robey" portable engines, one 10-in. gravel pump ("Sands"), one 10-in. nozzle pump ("Sands"), two lines of boxes of the following dimensions:—Length 104 ft., width 4 ft., depth 1 ft. 9 in. "Fall" allowed in the boxes, half an inch to the foot.

* *Vide* "Notes on Tin, Copper, and Silver Mining in the Stanthorpe District," by Lionel C. Ball, B.E., Assistant Government Geologist; G.S.Q. Publication No. 191, p. 17.

The fuel consumption up to the time of my inspection had averaged 4½ cords per nine-hour shift, the variety of wood used being mainly stringybark in 4-ft. lengths.

Some difficulty has been experienced by the management owing to the hard uneven bottom, which is crossed by numerous bars of aplite. The depth of alluvium met with up to the end of July, 1913, has varied from 3 ft. to 8 ft., but a depth of 24 ft. of overburden is known to exist in that portion crossing the main Ballandean road to the railway line. A fairly hard bed of "cement" is seen to overlie the washdirt in many places, but up to the present has not greatly hampered sluicing operations. The washdirt consists in the main of well waterworn pebbles of quartz and some angular fragments of aplitic granite. It is rich in tin in numerous isolated patches, but no definite leads had been located up to the time of my visit. The tinstone is mostly fine-grained and well waterworn, and is accompanied by much black sand and a very occasional topaz and some ilmenite. The tinstone is, however, very readily cleaned of black sand in the streaming box.

A "grizzly" is in use to assist in the removal of lumps of clay and stone, but compared to Emmaville and other tin-dredging areas, the amount of stone to contend with in the boxes is not excessive. A little tin occurs through the overburden. The present dredging site is on ground partly worked in the early days of the field.

Though the results of dredging operations at the present site have not been very encouraging, the syndicate owns a large area of freehold land, in which are deposits of stanniferous alluvium, particularly in the Glen Aplin area, from which better results may be expected. I understand that it is the intention of the owners to erect another plant on this site in the near future. Should later prospecting indicate that this alluvial is payable the dredge has many years' work ahead of it.

Dredging operations commenced about the middle of July of this year (1913) on portion 539, parish of Broadwater. Much of the area comprised within the 1,057 acres of freehold property could be classed as good orchard land. Speaking generally, it may be said that a lighter portable plant than that at present in use would be more efficacious for the particular class of material to be handled on such an irregular bottom rock.

Excelsior Sluicing Claim, on the Severn River, near Marstella's house (see Map No. 3), Ballandean district, 12 miles south-south-west of Stanthorpe. Owned and worked by Messrs. J. Mann and party.

This small claim is worked by means of a 4-h.p. portable engine, the material to be treated being carted on to the bank, and then washed with the water furnished by a 2½-in. pump.

This venture is of interest in that the idea of the owners is to pump out some of the very numerous deep water-holes occurring along the Severn River, and treat the loose material found along the bottom. In the case of the particular hole that had been pumped out at the time of my visit in June, 1913, the overburden proved to be from 6 to 8 ft. in depth, comprised of coarse sand and much rock fragments, under which was found the washdirt which was here 2 ft. in thickness of loose coarse sand and some sludge resting in turn on loose granite boulders along the hard rock-bottom. The syndicate has another large hole a few chains upstream to pump out and work in a similar manner. Occasionally exceedingly rich patches of tinstone (in washdirt ranging from 1 ft. to 1 in. in thickness) were met with behind the large boulders, the latter having acted as riffles to cause the mineral to be deposited along those of their sides least exposed to the scouring action of the currents in flood times.

Three men working shifts for three days and nights continuously succeeded in emptying the water out of the hole by pumping, but it should be remembered that no water was being received into the hole from the Severn River, which had practically ceased to run, owing to a long spell of dry weather. Including the time taken to pump the hole, these three men earned on an average £4 per week per man by their venture.

Operations were commenced in April, 1913, and about 4 cwt. of tin had been won up to the time I saw the claim.

There is usually an abundance of water easily available for sluicing. The country rock is coarse acid granite seamed with many dykes of aplite and infrequent small diorite intrusions.

A moderate amount of black sand is met with. The tinstone is stated to have averaged from 4 to 6 oz. per dish. It is mostly fine and well waterworn, consisting of black, ruby, and amber tin of high purity. The banks of the stream had been worked for tin in the early days, but no attempt had ever been made hereabouts to work the deep holes in the stream-bed.

Some excellent topaz has been obtained from the Severn River, both here and in the neighbourhood, during the tin sluicing.

Johnstone's Claim, owned by A. Johnstone, is located a short distance upstream from the Excelsior property, on the

Severn River. At the time of my visit in June, 1913, the bed of the stream itself was being worked. The river alluvium has here a great width and is composed in the main of granite sand resting on some 3 in. (average) of fairly rich stony wash, the gravel being very much waterworn. The tinstone is medium to fine in grain; parcels have averaged 75·1 per cent. of metallic tin. Very little black sand is present, except along the right bank of the creek. Odd topaz are found. Sometimes a fine sandy wash lies in the overburden at a position of 1 ft. above the true bottom washdirt. The bottom is mostly decomposed granite overlain with rather numerous hard boulders. This claim is worked by Johnstone and five Chinese on the share system. An 8-h.p. "Buffalo Pitts" portable engine supplies the power for pumping the water from the "paddocks" and for sluicing purposes. When on light work the engine requires the consumption of one load of firewood per shift, but three times that amount is required when on heavy work. Gum and box have been found to be the most suitable fuel for the purpose. A 5-in. gravel pump, reduced to 4-in. piping, is in use. The washdirt is wheeled to the sluice boxes. A bush-covered tail race is carried forward through the sand to permit of the water being used over and over again. There is little chance of stoppages by floods in the river hereabouts as the stream has been diverted temporarily to the edge of the channel, in addition to which the presence of the great quantity of loose sand would usually prevent the stream from flowing except after very long and heavy rain.

On portion 535, parish of Marsh (on the Severn River), a moderate amount of shallow "surfacing" on granite has been carried on; much well-waterworn quartz gravel occurs.

Curtain and Pettiford's Claim, on an ana-branch of the Severn River close to its junction with Accommodation Creek, Ballandean. The overburden is mostly loose, coarse sand lying among huge boulders of "Stanthorpe" granite which latter rock is here seamed with numberless veins of aplitic granite. A fairly extensive hole has here been pumped out by means of a small oil engine. The washdirt is mostly coarse sub-angular fragments of granite with a little waterworn quartz. Occasional topaz have been found. In this limited area of wet ground strewn with boulders the owners have adopted perhaps the only feasible method of work, dredging being quite out of the question under the circumstances.

NINE-MILE CREEK (ALSO KNOWN AS THE TEN-MILE CREEK.)

Mr. G. Bambery and his sons were working a small alluvial claim in front of their residence, near the Camping Reserve 11 at Mallow, on a bend in the stream channel, parish of Pikedale, 12 miles west of Stanthorpe.

The overburden here consists of seams of heavy black clay containing bands of granite sand. The bottom rock is extremely uneven. The presence of much clay through the washdirt itself causes some difficulty in sluicing the material for tinstone as the latter is picked up and rolled out of the boxes. The overburden becomes much deeper towards the western edge of the alluvial flat; small amounts of tinstone are found through the sandy seams occurring in this material. The washdirt consists of coarse angular granite and slate fragments, the deposit being close to the margin of these two formations; it is up to 2 ft. in thickness and carries coarse angular ruby and black tin, accompanied by topaz. The mineral has been deposited here owing to the existence of a well-marked granitic dyke crossing the stream at a bend, above which it would naturally collect. There is usually ample water for sluicing.

I was informed by the owners that they had taken out about half a ton of tin from this claim up to the end of June, 1913.

THIRTEEN-MILE CREEK.

Thirteen-mile Creek is one of the upper left bank tributaries of Pike's Creek, which latter it joins on portion 35, parish of Herries; it takes its head on the western fall of the ridge of "Stanthorpe" granite, which separates the parishes of Pikedale and Marsh; about 12 miles north-west of Stanthorpe. A moderate amount of tin has been won from the main stream, especially at its junction with Tabletop Gully, Swiper's Gully, and Bald Rock Swamp, near the western boundary of the parish of Pikedale. Swiper's Gully has been worked more or less throughout its length. Six dredging leases were pegged out along the creek recently for Messrs. Jamieson, Johnston, and McDonald in the interests of Southern investors, but no work had been done up to the time of my visit in June, 1913, other than to bring a portable engine to the site for future sluicing purposes. Topaz abounds through the alluvials here. The patches of alluvial are separated by very numerous hard bars of aplite and "Stanthorpe" granite, and the area appeared to me to be unsuitable for anything other than sluicing. The tinstone is mostly black and well waterworn. Tin has been obtained in small patches along several of the tributary gullies hereabouts.

Part II.—BALLANDEAN DISTRICT.

In this district considerable activity is being displayed at present in connection with the lode tin mining at Red Rock Creek, Carpenter's Gully, Stanton, and Sundown. The three first named localities are in juxtaposition, being situated along Red Rock Creek and its tributaries midway between the Severn River and the border Range, about 7 miles south-west of Ballandean Head Station, and 25 miles (by road) from Stanthorpe, parish of Ballandean, county of Bentinck; whilst the Sundown area lies about 1 mile south-west of the nearest point (Carpenter's Gully) of the area referred to.

The accompanying geological map shows the essential rock formations to be Permo-carboniferous (Lower Bowen) sedimentary rocks ("Trap Rock") intruded by the fine-grained acid ("sandy") granite, and hence they present no difficulty. These two formations are fully described in the chapter dealing with the general geology in Chapter IV., as also are the pegmatite veins seen along Red Rock Creek close to the north-east corner of M.L. 126. As the area is markedly rough and precipitous, it has been deemed an advantage to show the topographical features as accurately as possible under the circumstances. The positions of the cliffs as shown on this map may be taken as fairly accurate. A glance at the map will show the area of the granite to correspond closely with the topography developed, this rock having been exposed as a result of the denudation of the slates by a youthful stream system, the underlying formations thus being exposed. The Red Rock area may thus be considered as an island of granite surrounded by the older Lower Bowen sedimentary formation.

To the intrusion of this heated mass of acid granite into the cold overlying slates we must look for the origin of the lode-tin deposits in this district. As might be expected, the lode-tin workings are confined almost entirely to the periphery of the intrusive granite boss.

Looking over the deep gorges of Red Rock Creek and its tributaries, and calculating the amount of material that has been swept down through this channel, one might have expected, at first sight, to have seen a rich deposit of stream tin at the creek, but an examination of the latter shows the stream to be still in an extremely youthful stage of growth, and hence any tin that has been carried down the steep hill sides to the bottom has been swept clean away by flood waters and spread out too sparsely

into the Severn River to allow of any extensive payable deposit accumulating anywhere along either stream channel.

In my opinion it is probable that the lode deposits are practically confined to the contact zone, and the metals present will be found to follow this zone under the high slate ranges (*e.g.*, Mount Lofty) bordering the area at present accidentally exposed by denudation.

Though this field had been prospected about 40 years ago, the failure to find large deposits in this still nearly inaccessible locality, added to the low price ruling for tinstone for a long period, caused it to be abandoned. The district became covered with an impenetrable growth of rosemary scrub, and it was not till a short time ago that the passage of bush fires over the country rendered it possible, as a result of the prospecting operations of Messrs. W. Lynam and Eli Marstella, for mining operations to be resumed.

Mr. E. O. Marks, B.E., late Assistant Government Geologist, visited the field last year, and his report (accompanied by a series of photographs) will be found in the pages of the "Queensland Government Mining Journal" for November, 1912.

Mr. S. B. J. Skertchly, late Assistant Government Geologist, also visited the area in 1897.*

The accompanying extract from Mr. Marks's report shows this field to have been known as a possible tin producer for many years†:—

> The occurrence of tin in the neighbourhood of Redrock has been known for many years. Mr. Rands having visited the locality so far back as 1883,‡ when he saw a couple of small trenches cut across a vein of quartz from 20 in. to 2 ft. in width, in which there were small veins and bunches of tin ore. This work had been done some time previously. Mr. Rands again visited Redrock in 1890, and no work appears to have taken place during the intervening period.
>
> In 1897 Mr. S. B. Skertchly reported on the Stanthorpe District, including Redrock. No work appeared to have been done in the interval between Mr. Rands's and his visits. Though thus unable to see any workings, Mr. Skertchly formed an opinion from the surface features that there was a probability of the existence of true vein stuff.
>
> In 1904 Mr. L. C. Ball reported on the district. He mentions two claims being worked on what is now Carpenter's Gully.
>
> In the annual reports of the Warden mention is made of the discovery of lode tin at Sundown in 1893, but no mention of Redrock is made till 1908, when the Carpenter's Gully Company sank two shafts to 100 and 106 ft., respectively, abandoning their leases in the following year.

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* G.S.Q. Publication No. 120.

† Queensland Government Mining Journal, November, 1912, p. 538.

‡ Annual Report of Department of Mines, 1883.

KILMINSTER.

Several ore-bodies have in the past been found over the extensive area once known under the general name of *Kilminster*, situated near the Severn River, some 6 miles due west of Ballandean Railway Station. The principal of these workings were Watson's Show, Cannon's, the Queen Mine, the Lord Nolan, &c.

Watson's Show (also known locally as *Thompson's Folly*).—An adit was driven for 100 ft. in a hill in slate country in a direction E10S, at a spot not far from the junction of the slates with "Stanthorpe" granite. At a distance in of 85 ft. a "monkey shaft," 50 ft. in depth, was sunk by Eli Marstella, on contract, following the westerly underlay of a lode; and from the bottom of this winze a drive for 25 ft. was put in northerly along the ore-body. The lode material consists of semi-transparent quartz veins carrying siderite, iron pyrites, copper pyrites, manganese oxide, zinc blende, arsenical pyrites, wolfram, galena, molybdenite, and tinstone. Silver is present in small quantity, as are also all the other minerals listed. The width of the lode is about 4 ft. At a depth of 25 ft. below the adit level down the winze the walls of the ore channel are slickensided. The ore, which outcrops prominently, was exposed on the ridge by a cutting which showed it to possess a westerly underlay and a N.N.E. strike; it here consists of numerous veins of quartz, which alternately split and reunite as followed along the strike.

About a chain further east of this lode, a parallel lode was met with in the same cutting, the ore in this case being narrow veins of crystallised white quartz carrying tin, wolfram, silver, &c., all in quantities too small to repay working where seen. A short distance northerly (along the strike of the outcrops) this vein was opened by E. Marstella in 1912, and samples broken off of it by myself show odd coarse crystals of black tinstone through the quartz.

Cannon's Claim was located on portion 14v, parish of Nundubbermere. This old shaft was over 100 ft. in depth, and was sunk at a spot close to the junction of slate with a "Sandy" granite outcrop. A quartzose greisen occurs here which it was thought would carry payable tin values, but, nothing to warrant further prospecting being found, the shaft was abandoned. A little silver (up to 25 oz. per ton) was obtained from the decomposed kaolinic material at the surface. Rich patches of "surfacing" (tin) were unearthed in close proximity to this shaft some years ago, and there appears to the writer no reason whatever why further discoveries of a like character should not

be made in this locality, more particularly at sites in juxtaposition to the actual junction of the slates with the fine-grained acid granite.

Between Cannon's Claim and the Queen Mine, on the Severn River, is a ridge of the "Sandy" granite which carries numberless quartz veins showing small quantities of lode tin, wolfram, and molybdenite. This ridge would probably well repay careful prospecting for further veins of these substances, but would probably prove to contain only small veins suitable for working by one or two prospectors, and not large continuous ore-bodies requiring the erection by companies of extensive machinery.

Queen Mine.—Close to the right bank of the Severn River, parish of Nundubbermere, 5 miles W.N.W. of Ballandean Station Homestead.

The ore-body here consists of copperstained quartz and slate along the eastern side of the No. 2 quartz-porphyry dyke in slate shown on the geological map of Stanthorpe. A considerable amount of mining was done up to about 1908, since when the workings have been practically idle. The ore was bagged after crushing and concentration, and then despatched to smelters for treatment. The lode at the main workings (at the 60-ft. level in the shaft) is stated to be 24 ft. in width, but I have no definite information on this point owing to the shaft being inaccessible and nearly full of water on the occasion of my visit in July, 1913. Chrysocolla, malachite, azurite, bornite, and red oxide of copper were seen by me in some of the ore from the oxidised zone. The shaft is said to be 160 ft. in depth, with the lode still showing at that depth, though much narrower than at the 60-ft. level. Judging from the outcrops of the dyke and also the rock brought to the surface, this shaft appears to have been sunk on the wall of the porphyry dyke. At the bottom level short drives are stated to have been put in along the lode both ways. At the main (60 ft.) level drives were put in in all directions through a very extensive lense of ore met with there. Much cubical galena and some mispickel occurs with the ore at this level. The quartz-porphyry is rather fine-grained and of a fairly even texture as regards the phenocrysts of quartz and orthoclase (the latter being sometimes twinned). The groundmass of this rock is mostly buff-coloured, turning pink on decomposing. In all probability it represents the latest phase of the granite invasions in this part of Australia. The dyke is stated by local residents to be traceable at least as far southwesterly as Mingoola. The ore appears to pass from copper pyrites into blebs of cubical iron pyrites and finally into altered

dyke rock. Rock crushers, rolls, and Wilfley tables were installed at this mine to treat the ore, the material being first crushed extremely fine. This plant was run first by Messrs. Osmetti and Mooney, but has since passed into the hands of Mr. Henry Benjamin. Water came into the workings when the river level was reached. An analysis of a hand-dressed sample from the "firsts" from ore lying at grass after the previous workings, selected by Mr. Hy. Benjamin, senr., and assayed on 28th January, 1910, by Mr. C. A. Derrick, showed the following chemical composition of the ore:—

Copper	4·2 per cent.
Lead	23·9 per cent.
Zinc	17·7 per cent.
Sulphur	16·7 per cent.
Iron	12·1 per cent.
Silica and insoluble	20·3 per cent.
Arsenic	Trace
Gold	1·9 dwt. per ton.
Silver	12·85 oz. per ton.

I am informed by Mr. Henry Benjamin, junr., of Stanthorpe, that several parcels of the concentrated ore from this property were forwarded to the Cockle Creek (N.S.W.) Smelting Works, from which the following returns were obtained:—

COMPOSITION OF CONCENTRATES FROM THE QUEEN MINE.

Date.	Gross Weight.	Net Weight.	No. of Bags.	Gold.	Silver.	Lead.	Zinc.	Sulphur.
1906.	T. C. Q. L.	T. C. Q. L.			Oz per ton.	%	%	%
28th Dec. ...	6 3 1 0	6 1 2 2	118	Trace	21·5	27·7	13	16
18th ,, ...	6 3 3 0	6 1 1 19	110	,,	43·7	37·1	14·5	15
6th ,, ...	5 19 3 0	5 17 3 15	121	,,	31·2	23·6	14	15
1st ,, ...	6 0 0 2	5 17 3 23	108	,,	59	39·3	14	20
15th Nov....	6 3 3 0	6 0 3 1	109	,,	43·1	38·6	14·5	17
15th ,, ...	6 0 2 0	5 17 0 13	126	,,	22·7	21·1	13·5	16

A further parcel of concentrates on the 30th July, 1907, gave a return (W. and F. Lempriere) of:—

85 bags (net weight 5 tons 5 cwt. 14 lb.) yielding:—
Silver, 61·3 oz. per ton;
Lead, 48 per cent.;
Zinc, 10 per cent.;
Copper, 2·4 per cent.*

Near the junction of the roads to the Lord Nolan and Queen Mines respectively from Ballandean, a band of crystalline

* Penalised as an impurity.

white limestone in the slate country has been opened by shallow trenches; the presence of this material within such easy reach of the mines is an important factor if smelting operations are conducted in this area at a future time. The limestone belt is crossed by a yellowish resin-like seam of garnet rock which strikes apparently north-north-east; this garnet has frequently been mistaken for tinstone by reason of its appearance and relatively high density; in fact, a large parcel of it, previously darkened by being smeared with burnt fat, was actually disposed of to an experienced tin-buyer at Stanthorpe a few years ago!

Copper King.—This lode was worked by Marstella and party recently. It is situated just above the high-water mark adjoining the bank of the Severn River close to Marstella's old homestead, between the Queen and Lord Nolan properties. The outcrop is in broken slate country, which is here dipping towards a northerly extension of the same dyke of quartz-porphyry as that on which the Queen lode, above described, is situated. The ore channel consists of a well-defined belt of crushed slate containing splashes of copper pyrites, iron pyrites, and galena, with chloritic and graphitic bands. The lode produces a prominent rather gossany surface outcrop, traversed by veinlets of white crystallised quartz. A wide shallow shaft has been sunk on the ore-body, but was full of water when seen by the writer in July last. If it be decided to sink on this lode in the future, an attempt should be made to test it at a depth sufficiently great to intercept it at a point near the quartz-porphyry dyke, against which it appears to be dipping.

Lord Nolan (also known as the *Mount Bischoff*).—This mine is situated in a belt of "Sandy" granite along the left (southern) bank of the Severn River about a third of a mile east of and on the opposite side of the Severn River to the Queen Mine.

A seam of greisen carrying wolfram, bismuth, and tinstone occurs through the acid granite near the main shaft. This shaft is 35 ft. in depth, and was sunk on a tin-bearing vein contained in numerous greisen seams in the granite. The ore cut out completely at the bottom as soon as a variety of the granite resembling porphyry was reached. The strike of a wolfram vein at this spot is E.N.E. Much loose tin was found on the surface, having been shed from the mass of greisen. The latter formation appears to pass out in depth, due doubtlessly to its probable

horizontal disposition. It alone here carries any appreciable quantity of tin ore. Coarse crystals of wolfram, associated with molybdenite splashes, are found in the quartz veins which here traverse the granite. Epidote is present in the mineralised portions of the granite. A battery was erected for the purpose of crushing the greisen, but operations soon ceased as insufficient ore was found to keep the plant supplied. A patch of nearly solid tinstone, weighing 2¼ tons, was found lying as a flat seam in greisen at the spot on the surface where the main shaft was subsequently sunk. The average depth of the payable tin-bearing portion of the area has so far been limited to the first 5 ft. from the surface. Small loose nuggets of shed wolfram were mined for amongst the surface soil along the western side of the low mound-like rise on which the tin ore is found. A narrow quartz vein, which produced some 1¼ cwt. of wolfram, was here opened by T. Marstella; the strike of this vein is E.N.E. A vein of arsenical pyrites carrying tin, and striking N. 10°E., has been opened by a shallow shaft on its southern outcrop on the boundary of the 10-acre lease; dip vertical.

The only prospecting work done by the Lord Nolan Company is represented by a small cutting in greisenised aplite on the boundary of the 10-acre lease. This cut yielded 8½ cwt. of tinstone at the surface, but entirely cut out at a shallow depth. An excellent example of one of the associated coarse pegmatites can be seen on the north-western side of the contact of the granite with the slate; these pegmatites have so far proved barren in this area. The company started operations in 1909, and erected a 10-head stamper battery with a Wilfley concentrator attached, driven by engine power. After much idleness, operations were recommenced on the 27th March, 1911, Mr. Butler being appointed manager. The area was afterwards taken up under the name of the Mount Bischoff Mine, but has since been again abandoned. The policy adopted by them of spending so much of their available capital on costly machinery before first definitely locating ore deposits in sufficient quantity to warrant same, cannot be too severely condemned. The general structure of this area is certainly favourable to the occurrence of rich "pockets" of tin and wolfram, in the surface greisenised portion, but it is highly problematical if it would pay to test this area for a second possible horizontal zone of greisen at a depth, or that such if found would be any richer than that occurring at the present surface level. It is probable that the extensive area of greisen occurring was formed near the upper

surface of the intruding granite magma during the curitic phase of magma differentiation, and hence the upper surface is likely to be the richest in metal contents.

RED ROCK.

This portion of the field takes its name from the very prominent wall of red granite which marks the spot over which Red Rock Creek falls from the high slate country into a deep granite gorge. Red Rock Falls present a fine sight during wet weather, but on most of the occasions when it was seen by the writer only a very limited amount of water was passing over. They are situated a few chains north of the high cliffs fronting portions 290 W., &c. (*vide* map).

Cypress pine is the most characteristic tree, and ti-tree scrub the scrub of the granite areas, while grey ironbark and rosemary mostly clothe the surrounding slate country.

The granite is divided up into blocks by master-joints running generally at an angle of 134 degrees, these being crossed by seams running at 48 degrees and dipping S.S.E. Still a third set of nearly flat joints, dipping N.W. at a low angle, are seen, forming "floors" which produce steep slopes downstream away from the cliffs proper.

The greater portion of the rock forming the cliff face at the northern end of the gorge to the north of Red Rock Falls is baked slate, the underlying granite passing out in a northerly direction. Water was pouring over this precipice at the time of my visit on the 2nd June, 1913, but I understand that it is mostly dry. The passing out of the granite, as stated, points to the fact that the main mass of this rock at Red Rock is in the form of a boss whose apex was probably somewhere in the neighbourhood of the Red Rock Falls area itself. In the slates near the northern gorge just mentioned are numerous small apophyses from the granite intruding radially from the parent mass. The slates hereabouts contain occasional rectangular fragments of chert. At several spots along the cliffs the marginal rock of the acid granite is (as in the case of the Stanthorpe area) a quartz-porphyry. The partial digestion of the invaded slates by that rock (quartz-porphyry) has resulted in places in the production of a rock of intermediate composition to which it

would be difficult to assign an accurate petrological name, the nearest approach being perhaps an intermediate felspar porphyry.

Red Rock gorge, immediately below the falls of that name, runs nearly east and west, while the prominent escarpment of Red Rock itself strikes at an angle of 225 degrees. The rock structures in this vicinity much resemble in general outline the famous sandstone cliffs of the Blue Mountains (N.S.W.), and the scenery is certainly majestic.

On the 2nd June, 1913, about half a ground-sluice head of water was pouring over the falls; the water falls rather as an extremely steep cascade than a true fall. A deep pothole has been gouged out of the hard granite in the creek bed a few feet above the spot from which the water leaps into the gorge below.

Immediately above the falls, along the stream channel, the granite becomes intensely hard and fine-grained in texture, containing numerous veins and blebs of quartz. The two most prominent veins (seen on the left bank of the creek at the head of the falls) strike at angles of 60 and 65 degrees respectively. The granite extends for a considerable distance up Red Rock Creek, having been exposed by stream erosion and hence follows the contours.

Several smaller falls are located along the creek above the main one, and the Beehive Company at one time had a proposition to erect a dam above one of these cliffs to provide water and pressure to work their leases along the right-hand side of the gorge some distance downstream below the main falls.

In places along the upper reaches of Red Rock Creek are numbers of veinlets of crystallised quartz through the granite, some exhibiting blebs of wolfram and tinstone.

This portion of the granite-slate contact seems to demand more careful prospecting than appears to have been bestowed upon it in the past.

By far the most important workings carried out to date are the shallow cuttings made by the Beehive Company at various points along the contact zone, in which seams and veins of tinstone, usually accompanied by greisen, have been exposed. Molybdenite and wolfram in small quantities are present with the tinstone in several of the openings. The prospector, Mr. Marstella, informs me that he has won about 30 cwt. of tinstone

from the surface deposits, while about 4 tons of 26 per cent. ore are said by him to have been despatched by the present company. The decomposition of the numerous stanniferous greisen, &c., veins has caused a certain amount of tinstone to be concentrated amongst the surface material immediately below the contact down the side of the gorge to the creek bed. It is the intention of the present company to build a large tailings dam in Red Rock Creek from which to pump water to a height of about 500 ft. up the side of the gorge. A small plant is to be installed also at the point to which the water is raised for the purpose of giving added pressure to that afforded by gravitation. The loose material will be sluiced completely off the surface, and the tin caught towards the bottom of the ridge. By this means the numberless veins of lode material in the granite bedrock will be clearly exposed, and the business of prospecting these can be then entered upon to see if the hillside itself would repay working *in globo* as lode matter, or whether only the individual veins themselves should be worked. In the present state of the knowledge afforded by prospecting here to date, the best policy for this property is that of obtaining the large quantity of available "surface" tin before any possible future lode mining is entered upon. Throughout the area are numbers of small loose blocks of stanniferous greisen broken off the contact zone; these should be stored aside for battery treatment subsequently. A road was being made around the ridge from the old Sundown track at the time of my second visit to this district in August, for the purpose of enabling the pumping machinery to be landed at the sites of operations. As compared with the road that has been constructed to the Sundown Mine, in the same district, this road should not present any insurmountable engineering difficulties or be excessively costly.

Details of the various workings at this property will be found under the headings of the Beehive Company's leases.

Clark's Block.—M.L. 114; area, 10 acres. This, the most easterly of the leases in force at Red Rock at the time of my visit, has been taken up to prospect the contact of the granite and slate, the latter formation occupying roughly the northern half whilst the south-eastern portion takes in outcrops of the former rock. A small dyke of red pegmatite in slate occurs near the north-east corner of the adjoining block, M.L. 123; strike, E.W.; width, 6 in. It forms a remarkably clear-cut junction with the intruded slates along its short outcrop; crystallised

quartz occupies the centre of the vein in places. This dyke is almost certainly connected with the neighbouring granite intrusion below the surface. The granite itself is seen outcropping along the side of the steep ridge close to the gully shown on the plan. At prospecting hole No. 1 on the eastern face of the steep ridge, within a very few feet of the actual present granite and slate contact, occurs splashes of tinstone, molybdenite, &c. The tinstone is of a reddish brown colour, and occurs here in a very fine-grained variety of the "Sandy" granite, though it also is frequently present in a seam, 3 in. thick, of greisenised aplite, which passes insensibly into the acid granite. One seam appears to strike approximately south-east, and is accompanied by granular quartz. From this point southerly the junction of the two formations coincides with the edge of the cliffs, the harder granite presenting much greater opposition to weathering than the surrounding slates. These last-named rocks have been here severely indurated, and contain through them fairly numerous thin seams and veinlets of granite and quartz, radiating from the main invading mass of granite. Small greisenised seams abound in the granite near its margin.

At prospecting hole No. 2, close to the north peg of M.L. 124, and close to the northern boundary (near hole No. 1, on M.L. 124), the work done consists of two shallow adjacent holes, apparently in search of the stanniferous veins opened out in hole No. 1 of lease 124, about half a chain south-west of this spot, and described elsewhere.

Beehive Tin Mining Company, Limited.—This company owns several leases, situated along the right-hand side of Red Rock Gorge, some ¾ mile in a direct line from the falls. M.Ls. 121, 122, 123, 124, 125, &c. Mr. Eli Marstella, one of the prospectors, was in charge at the time of my examination of this district in June, 1913, but Mr. D. W. Kelly has since been appointed manager. Mr. Hy. Benjamin, solicitor, at Stanthorpe, informs me that there are 65,000 shares in this company at 10s. per share.

As Mr. Marks has already published a description of this property, and the present writer being in accord with that gentleman's observations, the following notes are to be considered as being additional information concerning the area:—

Workings 1B: About 28 cwt. of solid tinstone is reported to have been taken from this shallow cutting in hard granite close to the contact with slate. The granite is here extremely fine-grained, and contains small lense-shaped masses of greisenised

rock mostly striking east and west. The "surface" above the rock carries very fine brown tinstone composed partly of material so fine that it would be designated slimes.

Workings 2B: Some very rich "dabs" of tinstone occurred here which were bagged direct.

Workings 3B: A long cut has been put in along the cliff face in hard aplite containing greisen veins, which latter were found to carry fairly solid seams of tinstone when opened. Splashes of molybdenite occur through the rock near the tin, which latter is also accompanied by chloritic material.

Workings 4B: Quartz veins carrying tin are seen at this opening. The quartz is mostly crystallised, with a tendency to form in vugs. The samples taken by Mr. Marks for assay came from the soil adjoining this working place.* Two similar samples, taken by myself from this spot, on being washed gave a fairly high return—the tin being mostly coarser grained than elsewhere on the property, and also practically free from impurities. Several bags of tin were obtained from the surface soil hereabouts by the method of hand-washing known to miners as "banjoing." Up to 2 lb. per dish are stated to have been obtained at times from the soil here. Coarse crystals of tinstone are to be seen through the clay underlying the surface material.

Workings 5B: A small cutting has been made along the side of the steep ridge close to the contact line. Numerous pegmatite veins and seams of greisen carrying tinstone have been exposed. Veins of bluish coloured semi-transparent quartz are visible. Chlorite and tourmaline are present.

Workings 6B: A small cut, close to workings 5B. The tinstone is here in greisen veins associated with small veins of crystallised quartz which also shows tin. A vein of arsenical pyrites traversing the formations at this spot is stated to have yielded tin in payable quantity. A sample of solid arsenopyrite was dollied for me and gave a good result, the tin being mostly brown in colour and fine-grained. The "surface" hereabouts shows fine-grained tin.

Workings 7, 8, and 9B: These three cuttings, which were adjacent to each other, have since been connected. The rock contact is well seen in these workings, the granite being clearly seen to underlie and intrude the slates. Veins of greisen occur through the former rock. Strike of cleavages, in both the granite

* Queensland Government Mining Journal, November, 1912, p. 539.

and slate—north-east. The stanniferous portion appears to be frequently horizontally disposed at this spot between the two formations, indicating an *exact contact* deposit.† Crystals of cairngorm are common in No. 9 workings, being found in vugs and veins through the granite.

Several small potholes have been sunk along the surface contact of this flat occurrence, in most of which crystallised tin (in greisen) is visible. The tin has here been traced at least one chain into the granite.

Workings 10B: Situated on the edge of the cliffs. Patches of wolfram, with tungstic ochre and molybdenite with molybdic ochre, occur through the hard and extremely fine-grained granite. The wolfram is crystallised and occurs as radiating crystals in quartz veins. Pegmatite veins occur through the granite. An arsenical pyrites seam comes to the surface close to this cutting and is seen in an adjoining small costeen.

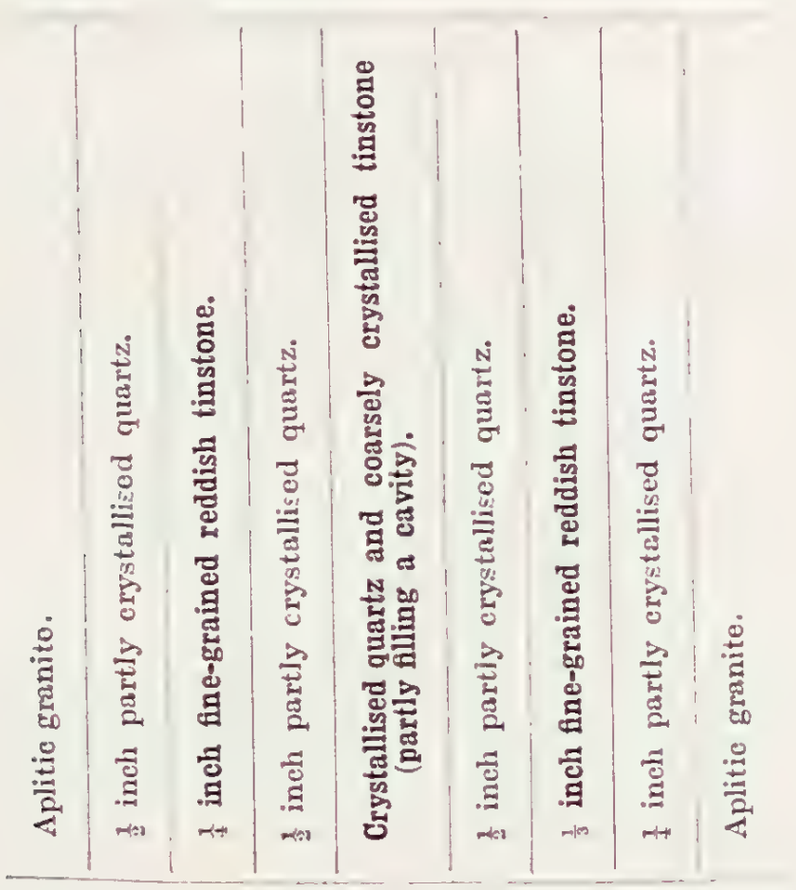
Lease 124.—This small triangular-shaped block of little more than 2 acres in area, adjoins M.L. 114 along the south-western side of the latter. It lies nearly entirely within the granite belt, but slate comes in near the north peg of the lease, where the junction of these two formations is easily seen, cliffs forming the actual margin of these rocks.

A little shallow prospecting (hole No. 1) has been carried out close to the north peg, near the northern boundary of the lease, at a spot about half a chain into the acid granite from the actual present surface contact, immediately under the line of cliffs shown on the plan. The cliffs at this point trend N.E. and S.W. The greisenised veins seen here run parallel to the cliff line along the same set of master-joints which originated the cliffs. The granite is very fine-grained and of a yellowish tint. A thin coating of secondary silica is observable at times along these joint planes. Small amounts of crystallised tinstone can be seen in places, as also a few flakes of molybdenite. The greisenised veins are of a somewhat redder hue than the typical aplite.

M.L. 121.—A large lease adjoining M.L. 124 along the latter's western boundary, and taken up to prospect the line of granite-slate contact passing through its northern half. Prospecting hole No. 1 is a shallow pothole at the foot of the escarpment on the northern side of a steep hill, close to the eastern boundary of the lease in its north-east corner. A small

† Cf., also the well known similar contact deposit at Silent Grove, Torrington (N.S.W.), which is less than 20 miles from Red Rock.

greisenised vein of fine-grained sugary quartz occurs here, carrying a little coarsely crystallised tinstone. A section of this seam revealed the following structure:—


Aplitic granite.
½ inch partly crystallised quartz.
¼ inch fine-grained reddish tinstone.
½ inch partly crystallised quartz.
Crystallised quartz and coarsely crystallised tinstone (partly filling a cavity).
½ inch partly crystallised quartz.
⅓ inch fine-grained reddish tinstone.
¼ inch partly crystallised quartz.
Aplitic granite.

Near the summit of the cliffs about a chain north of this hole a smaller seam of crystallised white quartz, from 1 to 3 in. wide, can be seen on the cliff face, striking east and west. It shows rather large blebs of crystallised wolfram and flakes of molybdenite. The wall-rock has been markedly silicified by the materials which produced the quartz vein.

The Beehive Company having adopted certain numbers for the various sites opened on their leases, of which this is one, it has been decided to assign the same numbers in this report as those in use by them, consequently, in referring to these workings by number I have added "B" after the distinguishing numbers in each case.

12B Workings: These are situated at the junction of the granite and slate at the top of the cliffs. A dyke of greisenised granular quartz (altered aplite) has been opened by a shallow cut on the southern side of the hill.

11B Workings consist of a round hole in hard quartzose aplitic granite on the junction of the slate, at the edge of the cliffs and about 130 ft. west from No. 2 hole. The rock junction can be well seen in this opening. Arsenical pyrites, copper

pyrites, pale bluish-green seams of slightly greisenised quartz occur throughout the rock mass. The quartz is characteristically glassy.

M.L. 123: This lease, belonging to the Beehive Company, lies to the north of M.L.'s 121, 124, and 114, and is entirely within the slate area, though very close to the contact zone.

Workings 13B are situated some 3 chains from the S.E. peg, near that boundary of the lease. A cut has been made on the southern side of the hill into a reef of granular quartz. The material of which this latter formation is composed undoubtedly represents an intrusive dyke, of highly siliceous composition, extruded during the final stage of cooling of the main granite mass. The dyke is 1½ chains into the slates from the present actual granite-slate boundary. It is identical with the so-called "quartzites" of Torrington (N.S.W.), and has had the same origin. Strike, E.W., dips south. A moderate amount of arsenical pyrites has been taken from a seam of solid arsenopyrite along its southern edge on the eastern side of the cutting. The formation outcrops clearly on the surface for a distance of half a chain. Sericite is present in small quantity and gives to hand specimens a greisen-like appearance at times. The seam of arsenical pyrites is said to have yielded small quantities of tin on being subjected to a fire assay.

Sheep Station Creek (also called *Shepherd's Creek*) is a left (south) bank tributary of Red Rock, entering the latter by a deep precipitous gorge known as No. 3 Gorge. It heads on the western side of the Sundown road and pursues a general northerly course past the freehold blocks, portions 313w, 289w, 71w, 72w, 55w, and 288w.

Numerous quartz veins occur in fine-grained acid granite along the right bank of the creek in portion 55w, near the north-west corner of that block; strike east and west. These veins consist of exceedingly numerous parallel veins in juxtaposition, and are composed of semi-crystallised white quartz, which possibly ultimately junction with a similar occurrence towards the head of Red Rock Creek below the old Sundown road. The right-hand branch of the gully is mainly in hard granite with no alluvial material to speak of, but along the main (left) branch of the gully, along the eastern boundary of portions 288w, 72w, &c., occurs a moderate amount of alluvium on a slate bottom. This material was partly worked many years ago, but no very recent mining of any note has been done along the flat. The ruins of formerly existing storage dams testify to the fact that some tin was obtained here, but the absence of granite along

this creek, and also the comparatively limited area which it drains, point to a probably low value as a tin producer of this alluvial. The slate is traversed by thin veins of quartz and granite, which have possibly added their quota to the deposit of stanniferous material. An old dam exists on portions 289w and 71w, in the alluvial flat. The latter consists of black mud and a little white clay overlying a few inches of stony slate wash. I am informed by a prospector that he obtained a small quantity of bismuth in lode material up this creek, as also traces of platinum, but I have seen nothing resembling these substances in this locality so far. A quantity of quartz was obtained from the numerous veins for furnace purposes at the Sundown smelting works.

CARPENTER'S GULLY.

Carpenter's Gully is a short deep gorge, with generally cliff sides, forming a left bank tributary of Red Rock Creek, which it enters near the Beehive Company's dam in the latter stream. The lode-tin mining here also has been confined to the contact zone.

The only work in actual progress here on the occasions of my visits in June and August, 1913, was that being carried out by Messrs. Gilchrist and Johnson near the head of the gorge described below.

Gilchrist and Johnson's Claim (No. 159, Red Rock).—No. 1 shaft: Operations were being carried on here in an old shaft, said to be 140 ft. deep originally, sunk by the former Carpenter's Gully Company some six years ago. Tin was passed through at 60 ft., but was apparently either not recognised as such or was not considered of sufficient richness to warrant being followed. The slate rock is said to have continued down the shaft for a distance of 70 ft., when granite was entered and the shaft sunk to the bottom in that rock. A drive is stated to have been put in for a distance of 12 ft. in a north-north-east direction from the bottom, but nothing of value was met with. The shaft is now inaccessible below the 60-ft. level. After having been abandoned by the original company for some time, the claim was taken up by the present holders in 1909. They have put in a winze at a steep angle for a depth of 12 ft. at the 60-ft. level, from a point 8 ft. north-west of the shaft. The slate "country" is here traversed by veinlets and tiny seams of granite, the whole carrying odd patches of very fine-grained brown tin. The slate is extremely hard, and has undoubtedly been rendered so by the underlying granite mass. The tin-bearing seams have in most

cases a general east-west trend and dip to the south-west. No other metals of commercial value have so far been found to be associated with the tinstone at this shaft. The stanniferous veins occur from the edge of the shaft to across the southern wall of the winze. To a depth of about 5 ft. down the winze a crushing of 5 tons of stone was taken out at the end of 1911; this ore, which was despatched to Melbourne for treatment, gave a return stated to be 10 per cent. A previous crushing of ore from above the present winze staging, gave a yield, stated by the owners to be 3 tons, of fine-grained solid tinstone. A further 26 cwt. of tin ore is stated to have been taken out of this winze during the months of April and May of 1913. Tin is still showing in the working face. The very hard slate sometimes shoots badly, especially in small faces, owing to the shape of the "heads." No timbering is required. The bottom of the shaft was in dry rock. Where the tin is present in the granitic seams it is richest usually, occurring right through the seam, but at times it is found along the edges only thereof. The slate "floors" are most irregular in direction. A short drive, in a direction S.20W. from the top of the winze at the 60-ft. level, has been put in for about 3 ft., showing similar seams to those seen in the winze. A second drive at this level was put in in a W.S.W. direction by the former company in hard slate for about 15 ft., but revealed nothing payable. They also had put in a drive E.N.E. for 30 ft. at the same level (greater part now inaccessible) through slate with numerous seams carrying very little tin. Several vugs are observable through the country rock, carrying quartz and felspar crystals, but no tinstone. Chlorite occurs sparsely through these seams, which are stanniferous. The felspar is present sometimes as small octopus-shaped masses embedded in a bluish silicified slate.

No 2 shaft (now inaccessible) is situated in slate a short distance down the hillside from No. 1, closer to the edge of the precipitous granite gorge of Carpenter's Gully. This shaft was sunk over twenty years ago by McCook, as that prospector had found rich "surface" tin. Very coarsely crystallised black tin (crystals up to 3 in. in length) were found down to the 30-ft. level, when the slate became barren and the claim was abandoned after the shaft had been sunk to the 50-ft. level. The shoot of tin appears to have dipped down the hill towards the No. 3 shaft. Crystals of tinstone can occasionally still be seen on the upper walls of the shaft. Dendritic markings abound along the joints in the slates. Veins of crystallised quartz traverse the rock in all directions.

No. 3 shaft is located still further down the hillside in slate very close to the granite-slate contact and on the edge of the gorge. This shallow shaft was originally sunk to a depth of 20 ft., the last 3 ft. being in granite, above which was found 5 ft. of dark-coloured siliceous slate. The present holders have put in a drive for a distance of 21 links in a south-south-east direction through broken slate country carrying numerous patches of amber-coloured brittle quartz and some fluorspar. Arsenical pyrites (and also oxidised arsenopyrite) occur through the working face at the end of the drive. From the opening near the shaft, and from the upper portion of the shaft itself, rich tin ore taken out by Mr. Eli Marstella some time ago, since when Messrs. Gilchrist and Johnson inform me they have taken out about 30 cwt. of coarse tin from this shaft. The tinstone was found to be present in greatest quantity immediately above the dark band of silicified slate abovementioned. Fine-grained tinstone occurs underfoot at the present face. Greisenised rock is fairly abundant and the prospects generally are, in my opinion, that this site will ultimately prove the richest portion of the claim. The tinstone here occurs mostly as very fine-grained material, which becomes gradually coarser as the central portions of the tin-bearing masses of rock are approached. It is generally of very high grade; in fact, colourless to pale amber crystals were seen by the writer at this shaft. Seams of felspathic and quartzose granite are usually present with the tinstone.

No. 4 shaft adjoins No. 3 shaft on the northern side. It was worked by Messrs. Curtain and Pettiford about ten years ago, who obtained rich tin ore. The work done consists of an inclined shaft (at least 20 ft. in depth), which is now inaccessible.

The Department of Mines has granted a subsidy to the owners to prospect their property for tin under the direction of the Warden. On the occasion of my first visit to this claim, in company with Mr. Warden Wilson, operations were being carried on in the winze at the 60-ft. level in the No. 1 shaft, but the prospects of finding more payable ore at the No. 3 shaft were, in my opinion, so much more favourable that the prospectors were instructed to resume operations at the latter place. Owing to the difficulties experienced, as a result of rain-water filling up the drive at the bottom of the shaft, it was decided to bring in a tunnel from the side of the hill a few feet below the shaft mouth in order to permit of easy drainage. This tunnel will follow the same direction as the drive above, and will serve the additional purpose of testing the ground for the presence of lode matter closer to the true contact of the slate and granite.

The owners have recently found traces of tin through the rock covering an extensive area about the shafts and old cuttings, but no true lode had been exposed on the occasion of a visit by Mr. Warden Kennedy and myself in August, 1913. A lease of 30 acres (M.L. 145) has since been taken up by this party, as also one of 9 acres by Horsley Clark (M.L. 148).

The Bank Block (portion 523w).—This old 80-acre freehold block was taken up originally by F. T. Smith, and subsequently passed into the hands of a banking company; hence its name. I understand that it is now owned by Mr. Gordon, of Sugarloaf. Owing to the great period that has elapsed since this block was surveyed and the nature of the country, some difficulty was met with in locating this area on the ground.

About two-thirds of the central portion of the area is occupied by granite, slate forming the outcrop on portions of its south-eastern and north-western corners. A considerable amount of lode tin has apparently been taken from one or other of the numerous outcrops worked, but I am informed by Mr. Gordon and also by old prospectors of the field that the workings in this almost inaccessible locality have not been carried out by the owners.

No. 1 workings consist of a small cutting in hard aplitic granite close to the edge of the cliffs on the right (east) bank of the gorge about 3 chains north-east of the north-east corner of M.L. 109. Nothing of remarkable value is showing here at present. The tinstone occurs in small irregular quartz veins. A little zinc blende, tourmaline, and specular haematite was observed. The quartz is mostly crystallised and was probably formed in vug-like lenses. The occurrence is at the junction of granite and slate. I am informed that a very rich patch of tinstone was found at this spot some years ago, from which 2 tons of mostly very coarse well-crystallised tinstone was taken. Vugs of amethystine quartz occurred through the tin veins. Near this cutting, on the downstream side of the cliff face, several circular patches of tin ore were seen by myself in the hard aplite, associated mainly with quartz veins.

No. 2 workings are also at the junction of the formations in hard aplite. Very rich patches of tin are stated to have been obtained from the bare surface of the rock, associated with quartz and felspar veins striking north 20° east. The workings are located on the top of a gorge towards the right bank of Carpenter's Gully. Some of the quartz is of a distinctly greenish tinge, due to chlorite. Occasional very large felspar crystals are found forming part of an extremely coarse pegmatite vein

accompanying that portion of the deposit which proved the richest in tinstone. In some instances isolated crystals of felspar, 2 in. long and as many wide, are found embedded in the apparently hard fine-grained aplite a foot away from the pegmatite veins. Prospectors told me that this deposit carried a quantity of huge crystals of tin in the pegmatitic portion, clusters of crystals of an aggregate weight of 2 cwt. being recorded. From fragments of crystals shown me, I am prepared to credit the great size stated to have been attained by some of the individual crystals, and it is regrettable that samples were not forwarded to a museum. Good crystals of such size are worth far more as specimens than their mere weight of tinstone.

No. 3 workings: On the northern face of a steep hill on the right bank of the gully close to the junction of a right-hand branch gorge tributary. A rich seam, striking west-south-west, was worked some years ago in a narrow cutting some 20 ft. in length and 15 ft. in depth. The tin occurs in quartz veins, and can still be seen along the western wall; it is coarsely crystalline. The quartz vein carrying the ore is still showing in the face at the southern end of the cutting. The rock around the tin ore is mostly stained green by chloritic material.

This block of ground appears to offer good inducements to prospectors to test the tin veins which occur on it, but the fact that it is privately owned has militated largely against any extensive mining operations being conducted on it in the past.

Curtain and Pettiford's (M.L. 130).—On the ridge along the southern side of Carpenter's Gully, a few chains south of the Bank Block, and adjoining the northern sides of M.Ls. 109 and 120. Area, 10 acres.

A shaft over 100 ft. in depth has been sunk following the north-westerly underlay of a stanniferous arsenical lode in slate country at no great distance from the contact of the latter formation with the intrusive "Sandy" (fine-grained acid) granite, which here occupies a portion of the north-eastern section of the lease. The shaft was not safely accessible at the time I examined this area early in June, 1913. The arsenical pyrites lode outcrops at the surface, where it has a strike approximately north-east (similar to that seen at the lode of arsenical pyrites carrying tin that occurs at Sundown (*Vide* page 129). The lode has been exposed in two cuttings to the south of the shaft, and also in several openings to the north of it. This main shaft was sunk vertically from a position off the lode so as to intercept the ore at a shallow depth; after reaching the vein the shaft was

carried down on the lode channel to the bottom. Wherever showing in the open cuts the lode averages about 2 ft. in width, and is composed of fairly compact arsenical pyrites and much hydrous arseniate of iron, carrying coarsely crystallised red and brown tinstone. It is stated that the lode is of a fair width, and shows good tin values for a considerable distance down the shaft from the 30-ft. level, where it was intercepted, but that at the bottom level the shaft is not actually on the lode channel, but I did not have an opportunity of safely examining the face. About 5 tons of tin ore was despatched for treatment in the early part of this year. I understand the claim is at present (1913) under option to Mr. Claude Musson. I am informed by Mr. T. Marstella that at a depth the walls of the lode show slickensides, a feature which confirms the view that the ore-body has been deposited along a master joint in the slates, which has since been further opened by movement along this same line of weakness. He tells me that 6 tons of solid tinstone were taken from one of the cuttings on the lode.

Long's Block (M.L. 139, Carpenter's Gully)—adjoins Curtain and Pettiford's block to the left-hand side of the gorge. Area, 25 acres.

A small cut has been put in along the claim boundary on the same line of lode as that opened in Curtain and Pettiford's (M.L. 130). The workings are now out of repair, but the lode can still be seen at the southern end of the cutting. Some rich patches of very coarse tinstone were obtained when the vein was first opened. The arsenical pyrites lode still preserves its north-east strike and north-west underlay, as seen at the main shaft of M.L. 130. It is probable that this is the result of the filling in of the original cleavage planes in the slate. About 2 chains northerly along the lode from the lease boundary small cuttings were put in many years ago, but the lode where then struck appears to have been much narrower than where exposed in the later workings; however, some rich specimens of "surface" tin were shed from this portion of the vein. The lode is traceable for a distance north-easterly through this block from the above-mentioned working places.

Musson's Block (M.L. 120).—A similar parallel vein of arsenical pyrites in slate occurs some chains from the junction of the granite and slate on the left bank of Carpenter's Gully along the steep hillside above the confluence with its main left-hand branch. Seams of granite, about 1 in. in width, traverse the indurated sedimentary rocks hereabouts, and several "dabs"

of richly stanniferous ore were obtained alongside these acid veins. Seams of greisen also usually occur here in those portions which have yielded the most tinstone. Very coarsely crystallised tinstone was found in veins half an inch wide occupying north-east jointings through the slate, felspar frequently forming the matrix in which the crystals are set.*

STANTON.

Benjamin's Block (M.L. 129).—Red Rock Creek runs diagonally across this block in a north-westerly direction; area, 26 acres. The granite, which has been exposed by denudation along either bank and in the bed of the stream, occupies about two-thirds of the total area contained in the lease, slate being seen at the north-eastern and south-western corners. Along the north boundary odd veins of aplite and numerous thin veins of crystallised quartz traverse both the granite and slate formations, those in the granite occasionally showing blebs of tinstone. Several seams of greisenised rock were observed.

An outcrop of dark red lodey material, making into quartz blows in places, occurs on this block, near the contact of the two formations above the right bank of Red Rock Creek; strike west 10° south. No prospecting had been done to prove the presence or otherwise of tinstone in this lode.

In land that was vacant at the time of my visit on 6th June, 1913, just to the north of the adjoining M.L. 131 and east of M.L. 129, a vein of crystallised quartz occurs at the actual junction of the two rocks. The veinlets of granite, traversing the slates at this point, are clearly visible. An insignificant amount of tinstone occurs as sparsely distributed specks through the quartz and its adjacent slate and granite wall-rock; strike of the vein, North-west and south-east.

Clark's (M.L. 126).—A small lease along and including Red Rock Creek, adjoining the previously mentioned M.L. 129 along the latter's north-western portion. Area, 10 acres.

Towards the northern boundary of this block, in the bed of the creek, occurs the pegmatite veins and porphyritic aplite at the junction of the slate and granite. (*Vide* figure 2.) As this interesting formation has been described in the full report dealing with the general geology of the area, it will not be so treated in this section, which specially deals with the mining

* The process of removing crystallised tinstone or other metals from the joint planes of rocks is known to miners as "scabbing."

industry. A few chains downstream, just at the spot where the creek tumbles over a low fall, the actual junction of the two main rock formations is also well marked, especially on the right bank, where tongues of extremely fine aplite and acid granite intrude the surrounding slates. The general bearing of the contact line at the falls is west 10° north, the strike of the apophyses being mostly in the neighbourhood of north-west, which latter corresponds with the very straight line of junction between the formations from the pegmatite to this spot. The slates at this spot have been highly silicified by the invading granite mass. Tiny seams of aplite traverse the sedimentaries in places a few inches from the main line of contact and maintain a general parallelism thereto. At about 2½ chains easterly from the south-west peg the granite is seen intruding the slates, and forms a marked bluff-like outcrop. In the immediate vicinity of the junction several horizontal seams of this rock, up to 1 ft. in thickness, radiate out from the main boss into the slates. The occurrence of the tinstone here, as elsewhere in the district, is along the contact zone.

The slate is somewhat shattered, and in places approaches to a breccia in structure. Seams of greisen with chloritic material are found through this rock, having a horizontal disposition in general coinciding with "floors" in the slate, but undoubtedly owing its origin to the adjoining igneous rock to which they are attached by veinlets of quartz, &c. Several shallow cuttings had been put in just prior to my visit on 6th June, 1913. Biotite and tourmaline in small amount accompany the greisen seams in places. The lode tin is visible at times in the form of coarse black crystals. A pothole east of the workings is in slate near an intrusion of granite from the main mass, operations now being carried out on the north side of the intrusion. The greisen is seen here as rather steeply inclined veins, and is still visible at the bottom of the hole. In the easternmost hole (known by the owner as No. 3 east) about 100 ft. west of the main contact and on the north edge of the branch intrusion, a small patch of greisen carrying coarse black tin was opened, having been traced by loaming. In the next westerly cutting an arsenical pyrites vein up to 1 ft. in width, on being opened out, proved to underlay south and carry payable tin ore; its strike is very slightly north of east. The hanging-wall of the vein is particularly well defined. A little greisen and sericitic material is in the ore-body with the mispickel itself. At No. 2 east prospecting shaft large crystals of brown biotite in masses occur as seams in a greisen lode.

At No. 1 shaft (shallow) a fairly rich seam of tinstone was seen in greisen at the bottom along the southern side of the shaft, the arsenical vein (here 1 ft. in width) carrying tin being also visible along the northern side of the shaft. Traces of copper pyrites were noticed by me in the ore from this shaft. In the shaft (shallow) known as the prospecting shaft a seam of greisen carrying tin is seen, dipping south, and will probably be met with in the No. 1 shaft by driving in a south direction. In the shallow shaft known as No. 1 west, the slate is much broken and settled country did not appear to have been reached; a seam of quartz, running parallel to the main line of lode, occurs along the southern side of the shaft, whilst a little greisen showing tin is located in the slates at this spot. The No. 2 west (westernmost) is a shallow hole apparently at the junction of the granite and slate, but mainly in the latter formation. The quartz reef still continues in this opening, showing at times splashes of black tin. Westerly beyond this hole numerous greisen veins in the slates can be seen on this lease. At a spot some 2 chains easterly from the western boundary of this block a small cutting has been made in what appears to be a similar occurrence to that seen at the No. 1 shaft, the ore being essentially chlorite with arsenical pyrites and sericite. Tin is found in the loam below this vein, but nothing of value had been found in it up to the time it was examined by me; strikes east and west and exhibits a slightly south underlay where seen at the surface.

North-westerly a few chains beyond the north boundary of this lease the granite passes out at the base of the second falls in Red Rock Creek at Henry Collins's grazing area fence. A strongly marked set of cleavages resulting in a straight wall on the right bank of the stream is to be seen here, striking east-north-east and dipping south.

This portion of the field is well provided with drinking water, as two deep pools have been formed in the rocky bed of the stream immediately under the low falls above referred to.

Collins' Block (M.L. 127).—A small (5-acre) block adjoining the western boundary of Clark's (M.L. 126) along the north and west slopes of a ridge to the south of Red Rock Creek, and mostly within Henry Collins's grazing homestead area, portion 102. This was the most westerly lease in force at the time of my visit. The country rock is all slate with the exception of a very limited area of granite belonging to the branch intrusion on the western boundary of 126. Odd greisen seams were noticed along the eastern portion of the area, but the lode opened in Clark's

block was not visible, though the latter may well be expected to extend westerly into this claim. No work was in progress when the area was seen by me, and the only prospecting that had been carried out was that represented by very shallow trenching, which revealed occasional small veins of pegmatite.

Westerly beyond this block about a quarter of a mile a small pothole has been sunk on a greisen vein in slate, showing a little tinstone. If this should ultimately prove to be identical with the greisen formations being worked at Clark's, the tin lodes in the latter property might well be expected to pass into Collins's lease. Deeper trenching in a direction at right angles to Clark's lodes, and careful surface prospecting by loaming about the strike of those stanniferous formations, are strongly recommended.

Portion 831w.—This long narrow area, fronting the southern bank of Red Rock Creek, was taken up a great number of years ago, but is not now in force. It is partly covered by M.Ls. 130, 129, &c. The northern and south-eastern portions are occupied by granite, slate country being found over the remaining major portion.

A small seam showing arsenical pyrites can be seen on the eastern side of the steep hill on which this block is situated. A little tin was discovered here recently by Clark, near the top of the hill not far from the slate-granite junction. The existence of several magnificent pine-trees near the junction of the gully which enters the main creek near the north-eastern corner of the block is of interest; these trees are certainly the finest specimens of their kind in the whole Stanthorpe region known to the writer.

SUNDOWN.

The Sundown area (M.Ls. 24, 27, 28, 110, &c.) consists of slates through which are numerous veins of tin and copper ore, the commonest mineral associate with the former being arsenical pyrites, whilst there also appears to be a close relationship between the tin and copper minerals themselves, veins which in places are cupriferous being found at short distances away to pass into lode tin ore and *vice versâ*.

A very prominent dyke of quartz-porphyry, seen as a bluff below the mine, has been described in detail in Chapter IV., on the geology of this district, as also have the ramifying system of associated diorite dykes and the tiny seams of tin in the surrounding slates.

The only mine being worked at the time of my visit in June, 1913, was the Sundown property itself, which is situated about 28 miles from Stanthorpe and 16 miles from the Ballandean Railway Station, and as I had only half a day available in which to make an examination of the whole field, the accompanying notes are issued as additional information to the already frequently published reports on this property.

From the mine to the summit of the range dividing it from Carpenter's Gully is a rise of 2,000 ft., but a long spur of moderate grade enables the ascent to be made on horseback.

Water for sluicing purposes is obtained from Sundown Creek, which flows close past the main workings. Owing to the amount of arsenic in the water from the mineralised veins this water is not potable after a spell of dry weather.

The veins of ore appear to occupy the main line of cleavages in the slate, and hence possess a north-east and south-west strike.

Sundown Tin Mine (M.Ls. 24, &c.).—On Sundown Creek, 2½ miles south-west of the Beehive property at Red Rock. Owned by Mr. T. Welsby.

This is one of the earliest lode-tin mines in this part of the State, and has been working almost continuously for over thirty years. At the time of my visit the shaft was full of water to the No. 2 level.

No. 1 level: Operations are at present (June, 1913) being carried on here. The drive shows the ore-body to occur along a master joint in the slates, the ore being formed in dumpy lenses, which are practically continuous with each other. A small amount of copper ore is observable at the southern end of the main opencut. Wolfram in very small amount also occurs here with the arsenical pyrites. The country rock is hard much-jointed slate. Seams of arsenic oxide abound near the surface, indicating the results of decomposition of the mispickel seams. It is estimated by the manager that about 9,000 tons of tin ore are already stacked at the surface containing some £2,000 gross worth of tin. At present the broken material is simply screened and the screenings then washed, the resulting concentrate (one bag of concentrates from three bags of screenings) being sent to market.

In this mine it has been noted that whenever the main fissure widens to permit of lenses of ore being formed along it, the tin contents in the ore increase also. Fluorspar, siderite (carbonate of iron), calcite, &c., occur with the arsenical pyrites ore here in a great many portions of the lode. From its general

appearance and structure, I am strongly of opinion that this lode will long continue to yield payable quantities of tin ore, and well warrants the erection of a small crushing plant at the mine, with additional appliances (*e.g.*, magnets) to extract the arsenical pyrites from the tin ore in the concentrated material. Two shallow shafts were sunk on an arsenical pyrites vein thought to be a north-easterly extension of the lode, but nothing of value was found.

The No. 2 level is at a depth of 44 ft. from the brace located at a depth of 20 ft. from the surface in the main opencut. There is a drive for 18 ft. in a north-easterly direction along a pay shoot in the lode which in the face dips to the north-east and pitches east-south-east.

A sum of £300 was granted by the Department to assist in the construction of a road over the rough range between Ballandean and the mine. The expenditure of this sum, in addition to a considerable amount of time and money devoted to this work by Mr. Welsby, has resulted in a fairly good road of access being made.

Sundown Copper Mine, also the property of Mr. Welsby, is situated on the opposite (right) bank of Sundown Creek to the tin mine just referred to.

A tunnel has been driven into the hill many years ago for a considerable distance along a well-defined copper pyrites lode in slate. At the end of the working face blebs of tinstone are visible, whilst copper pyrites ore appears at intervals along the drive, and has also been worked from several winzes below the tunnel. A furnace, still in a fairly good state of preservation, was erected and a fair amount of copper extracted. This lode also follows a master joint, and might almost be taken for a true fissure vein; the same remark applies to the Sundown tin lode. In a shaft (now inaccessible) on the opposite side of the hill, similar minerals occur in what is probably a continuation of the main copper lode. Copper ore was also obtained from what is known locally as Mann's property, the veins being thought by some to be connected with the Sundown copper lode.

Sundown South Mine.—This mine was idle at the time of my visit, and was not accessible. I am informed by the manager of the Sundown Mine that the upper 25 ft. in the shaft on the Sundown south lease carried copper ore, below which is a loose mixture of material composed mainly of iron ore with a small amount of tinstone.

Part III.—ECONOMIC MINERALS (other than Tinstone.)

Gemstones—

Diamond	Ruby	Cairngorm
Sapphire	Topaz	

Metallic Minerals—

Gold	Copper
Silver	Wolfram
Lead	Molybdenite
Zinc	Ironstone

Non-Metallic Mineral—

Limestone

In the "Queensland Mineral Index," G.S.Q. Publication No. 241, Mr. Dunstan gives the following list of minerals, hitherto officially recorded in publications, &c., from the Stanthorpe mineral field:—Gold (alluvial and reef); Silver (pyrargyrite); Lead (anglesite, galena, massicot, minium); Copper (azurite, chrysocolla, pyrites, cuprite, malachite, redruthite, tile ore); Tin (cassiterite, stannite); Bismuth (bismuthinite, bismutite); Wolfram; Molybdenite (molybdite); Antimony (stibnite); Manganese (psilomelane, pyrolusite); Zinc (blende); Iron (hæmatite, pyrites, magnetite, mispickel); Amethyst; Beryl; Cairngorm; Calcite; Corundum; Diamond; Garnet; Hornblende; Hyacinth; Jasper; Kaolin; Monazite; Orthoclase; Prase; Rock Crystal; Ruby; Sagenite; Sapphire; Spinel; Topaz; Tourmaline; Zircon.

The accompanying descriptions are of a few of the more important of those occurring in the area seen by the writer.

GEMSTONES.

Diamond.—Mr. Hume, Mineral Lands Commissioner, mentions the occurrence of a few small diamonds and sapphires from the alluvial at the junction of Spring Creek with the Broadwater River.*

In Mr. Skertchly's Report† reference is made to the finding of these gems in Kettle Swamp Creek, Spring Creek, and the head of the Broadwater.

Hunt's diamond-saving plant was erected on Spring Creek in the year 1873, by John Moffatt and party, but only three or four stones were obtained, and the plant was then removed to Kettle Swamp Creek, but failed to produce any of these stones. Occasional small diamonds have also been found, of late years, in the

* Report on the Queensland Tin Field, 1874; p. 24.

† G.S.Q. Publication 119, p. 83.

sluice-boxes at the dredging claims, notably at Four-mile Creek, at which last-named place those found are small, and of the typical straw colour.

A few small gems have been found in the stanniferous alluvials of Wylie Creek, Herding Yard Creek, Cemetery Creek, &c., on the New South Wales side of the range.

In my opinion the origin of the diamonds is, in the main, to be sought in the denudation of the numerous basic dykes (lamprophyre, dolerite, basalt, &c.) of Tertiary (?) age, described previously in the chapter dealing with the latter geological period. Mr. Skertchly's view of their genesis is as follows†:—"I think they are derived from the greisen, and suspect they are the crystallised portions of the carbon which gives the colouring matter of the cairngorms, the graphite of the slickensides, &c."

The date of the first discovery of diamonds in the Stanthorpe district was 1872 (at Spring Creek), those at Kettle Swamp, near Blue Mountain Creek, being found next year.

Sapphire.—These gems have been found from time to time in small quantities when sluicing the alluvials for tinstone. They are recorded from the Broadwater River, Spring Creek, Quart Pot Creek, Sugarloaf Creek, Lode Creek, Arbouin's Gully, Cannon Creek, Kettle Swamp Creek, the Severn River, Thirteen-mile Creek, Four-mile Creek, &c.

Mr. Skertchly suggests that these stones have been derived from the greisen, but the probable relationship of this variety of corundum to basalt in the case of the Anakie sapphire field, in Central Queensland, rather suggests a possible genetic relationship to the basic rock series, *c.f.* diamonds from dolerite.

Bright blue, pale yellow, green, blue, and pink-coloured gems are recorded.*

Ruby.—This red variety of corundum is of very rare occurrence both here and in Queensland generally. A fine stone from the Stanthorpe district is on exhibition at the Queensland Museum. The gem in this case was found in the stanniferous gravels associated with sapphire, zircon, &c. With the same minerals the variety *Barklyite* (a purple, opaque form) has also been recorded from here.†

Topaz.—This gemstone is very abundant throughout the *Recent* alluvials in the district, and is eagerly sought after by tourists as mementoes. The low price at which good cut stones

* G.S.Q. Publication 119, p. 83.

† Queensland Mineral Index. G.S.Q. Publication No, 241.

can be purchased abroad renders it very problematical if it would not often prove cheaper to purchase the latter than to pay the charges for having the stones cut in Australia.

I have seen some excellent blue-tinted topazes from this district, especially from Thirteen Mile Creek, but the average size of the stones found is rather below that of other districts—*e.g.*, Oban (N.S.W.).

It is usually an easy matter to determine the difference between these stones and quartz, with which it is always associated, as the topaz specimens mostly show signs of the perfect basal cleavage. The density of this stone is sufficiently greater than that of the quartz to be detected by those used to handling pebbles of these minerals.

Spring Creek, Thirteen Mile Creek, Broadwater River, Accommodation (Bald Rock) Creek, and Quart Pot Creek are among the streams in which this gem is commonly found, but topaz has been seen in the alluvials along every important stream in the district.

It is surprising how rare are specimens showing the original crystal outlines, most of the stones being well waterworn.

Cairngorm.—Several fine stones have been found at various times.

METALLIC MINERALS.

Gold.—The actual gold deposits are confined to the Lower Bowen slate country to the west of the granite belts of Stanthorpe, the principal areas which have so far proved productive being Pikedale, Talgai, Thane's Creek, Leyburn, Canal Creek, &c., in the Warwick district. As these fields are beyond the area comprised by Map No. 3, they have not been examined by the writer. Mr. Skertchly's report* gives a detailed description of many of the reefs. Gold is present in the silver-lead-zinc ore of the Silver Spur Mine (*vide* Notes on Silverspur, at the end of this Report), the whole of the slag dump at that mine containing an average of 8d. worth of extractable gold per ton. The ore here during 1910 was so rich in that metal that the matte sold carried an average of 6 oz. per ton, some £3,000 worth being won in consequence.

It is of interest to note that the alluvial deposits of Stanthorpe and Willson's Downfall situated close to the outcrops of Tertiary (?) basic dykes almost always contain traces of gold —*e.g.*, Cemetery Creek and Two Mile Creek, on the New South

* G.S.Q. Publication No. 119, pp. 51-79 & 86.

Wales side of the border, and Sugarloaf Creek and the Severn River on the Queensland side of the range.

Half an ounce of gold, very thin and waterworn, was found in the sluice-box at the Rover dredge, Four Mile Creek, near Stanthorpe; the area drained by this stream is mostly "Sandy" granite.

Mr. Skertchly records* gold in the tin gravels at Spring Creek, Cannon Creek, Lode Creek, Blue Mountain Creek, and Hunt's Gully.

Silver.—By far the greater portion of the 2,061,345 oz. of silver recorded from this mineral field has been won from the Silver Spur Mine, near Texas. This total output, valued at £234,361, constitutes 15·27 per cent. of the total State production of the metal to the end of the year 1912.

The silver-bearing lodes are practically confined to the Lower Bowen sedimentary beds, an exception being in the case of the small and valueless ore vein close to Mrs. Allison's house on the right bank of Sugarloaf Creek. Mr. Skertchly records the existence of a little argentiferous galena in specimens from the tin area between Red Rock and Sundown (Ballandean district).

A note on the Silver Spur Mine will be found at the end of this report. The mineral pyrargyrite is seen at times, notably in the quartzose portions of the ore, as thin seams through the lode lenses here.

Lead.—Galena is one of the essential metal constituents of the ore at Silver Spur, and the output of 1,044·75 tons of lead to the end of 1912, of an estimated value of £13,926, and representing 2·65 per cent. of the State production of that metal, has been mainly derived from that property. As in the case of the associated zinc, copper, and silver minerals, the lead lodes are practically confined to the slate areas.

Zinc.—Zinc blende forms a considerable proportion of most of the lenses of ore at Silver Spur, at which mine there are large bodies of zincy ore (sulphide) which up to the present have not yielded a satisfactory quota of their contents owing to the difficulties attending the treatment of such ores metallurgically.

Zinc blende occurs in small amount in the complex ore at Watson's show at the old Kilminster area, Ballandean district.

Odd blebs of zinc blende have been seen by me in the stanniferous ores in granite at Red Rock and the surrounding district.

* G.S.Q. Publication No. 119, pp. 51-79, 86.

Copper.—Some 1,144·75 tons of metallic copper, valued at £70,318, has been mined at the different centres—*e.g.*, Silver Spur, Sundown, &c. throughout the Stanthorpe Mineral Field, to the end of last year (1912).

Small amounts of copper ore are at times seen in the quartz veins traversing the granite areas, but the slate areas are more likely to yield payable quantities of this metal than the first-named formation in this region.

Wolfram.—This mineral is of rather common occurrence in very small quantities, but in no case so far recorded has it been proved to exist in sufficient quantity to warrant the opening of a mine to work the deposit.

It occurs more particularly within the granitic area classed as "Sandy" granite, notably at Red Rock, Kilminster, Lord Nolan, Lode Hill, &c., to which reference is directed for further information on the subject.

At the Beehive leases at Red Rock there is a moderate development of tungstic ochre along the cracks through the acid granite at its contact with the slate country.

A small quantity of massive wolfram was obtained from a quartz reef towards the head of Cannon Creek, about 2 miles from Mallow Post Office, some years ago.

Approximately 2 tons of wolfram has been won from the Stanthorpe mineral field to the end of 1912, valued at £188.

Speaking generally, wolfram may be said to be of commonest occurrence in this region in crystallised white quartz veins in the fine-grained acid granite and its apophyses along the margin of intruded slates and older granites.

*Molybdenite.**—This substance, the sulphide of molybdenum, occurs, in a somewhat more acid variety of the "Stanthorpe" granite than the usual form, in a railway rock-cutting 2 miles north of Stanthorpe, on Portion 3, Parish of Folkestone. It is present here in the form of very numerous small scales disposed as splashes along master joints dipping approximately east at a steep angle. While the aplitic veins to which this mineral undoubtedly owes its origin are not seen in actual juxtaposition

* The writer has since published a more complete account of the occurrences of molybdenite in this district; *vide* Queensland Government Mining Journal, April, 1914, pp, 184-9: "Molybdenite in the Stanthorpe-Ballandean Districts, Southern Queensland, with Notes on Molybdenum Minerals."

to it, the host rock is intruded hereabouts by numbers of such dykes, to an at present concealed one of which the deposition of the molybdenite is due. The molybdenite also occurs here sparsely along the east-west joints in the granite. A small pegmatite vein is seen near by in the cutting, and possibly has been indirectly connected with the genesis of the mineral. Towards the southern end of the cutting several parallel tiny fractures are visible, filled with molybdenite and quartz, and traceable for 20 ft. northerly. The granite on either wall of these veinlets is altered for a distance of two inches out from the vein. In one instance a pegmatite vein contains scales of the mineral. A pronounced outcrop of a dyke of a particularly quartzose variety occurs about one chain south of the molybdenite seams, and, as in the case of the pegmatites, belongs to the euritic phase of the granitic intrusions, to which is attributed the genesis of the mineral now being discussed. This last-mentioned intrusive dyke weathers to a characteristic yellow sandy clay, and the abundance of this material elsewhere in the district points to an even greater development of these later acid intrusives than mere rocky outcrops would suggest: strike 257 degrees; dip south at about 45 degrees.

This substance, which is becoming increasingly important commercially in steel manufacture, &c., also occurs as flakes of molybdenite and efflorescences of molybdic ochre in association with tinstone and wolfram at the Beehive and other properties in the Red Rock district, its mode of occurrence being usually in the most acidic veins in the "Sandy" granite within the contact zone between that rock and the intruded slate masses.

Some of the aplite dykes traversing the "Stanthorpe" granite along the border range in the Wallangarra district towards Bald Rock exhibit splashes of molybdenite.

It has also been observed in the greisen veins and most acid dykes in the Kilminster area, notably along the ridge between Cannon's Shaft and the Severn River.

Sparsely distributed flakes may be found in the fine-grained acid granite belt extending along the border in the neighbourhood of the Tick Gate on the Ruby Creek Road from Stanthorpe.

I have also observed it in small nests at times in the "Sandy" granite near to the line of junction with the older intruded coarse acid granite along the range from Sugarloaf Mountain towards Lode Hill.

A reference to its occurrence with tinstone in a quartz vein close to Sugarloaf Creek will be found elsewhere in the text.

Only £4 worth of this substance is recorded as having been won in the Stanthorpe mineral field up to the end of 1912.

Ironstone.—Bands of ironstone occur, mainly in juxtaposition to the limestone beds. in the Silverspur district (*vide* Notes on Silver Spur Mine).

A total of 806 tons, valued at £378, has been mined for use as a flux in smelting operations to the end of 1912.

For an analysis of this material attention is directed to Chapter VII., dealing with Silver Spur.

NON-METALLIC MINERALS.

Limestone.—Several leases for quarrying limestone have been worked at Gore, which is included within the Stanthorpe mineral field, but is outside the area covered by this report.

Limestone is abundant in the Silverspur district, also at Glenlyon, Kilminster, &c. (*Vide* Chaper IV., page 66, the Lower Bowen sedimentary formations.)

A sample of limestone from the Ballandean district was analysed in the Chemical Laboratory of the Department of Agriculture for Mr. T. Curtain, of Ballandean, and showed the following chemical composition:—

	Per cent.
Loss on ignition	41·90
Lime (as CaO)	55·50
Magnesia (MgO)	0·29
Iron and Alumina	0·18
Silica	0·46

The existence of good quantities of limestone at various localities through the field, especially at Silverspur and Kilminster, must prove of considerable economic importance in connection with future smelting operations.

A total of 14,190 tons of limestone have been quarried from all the deposits in the whole Stanthorpe mineral field (including the output from the Gore district to the end of 1912), the estimated value being £3,493.

CHAPTER VI.

AGRICULTURE.

In common with the majority of other mining fields in Eastern Australia, the attention of the population in the Stanthorpe district is, with the decline in easily-won mineral wealth, being steadily but surely directed towards the cultivation of the soil. Many of the tin miners had taken up small residential areas in the neighbourhood of their claims, and were naturally loth to abandon their homes when the production from the former rich deposits of alluvial tin fell below the paying point; they therefore then turned to the cultivation of fruit, cabbages, tomatoes, &c., for which this district is now justly famed. Apples, peaches, and plums are perhaps the most commonly grown fruit, and find a ready market both in Brisbane and Sydney at good prices. Ground is being cleared at suitable spots all the way from Dalveen to Wallangarra; during the time of my examination of this area the most extensive preparations for planting orchards were in progress at The Summit and Thulimbah. Fruit constitutes by far the greatest freight forwarded from most of the smaller railway sidings—*e.g.*, Roessler, Glen Aplin, Ballandean, &c.

With a view to affording information to the orchardists and others concerning the classes of soil met with in this district, Mr. Inspector J. Henderson, of the Agricultural Department, collected a number of representative soils for examination; a pamphlet* (by Messrs. J. C. Brünnich and G. R. Patten, of the Chemical Laboratory attached to that Department) has now been issued, giving particulars of the analyses, &c., of the several samples. The pamphlet is accompanied by a locality map showing the position from which the soil was taken in each instance. The following excerpts are taken from the report abovementioned:—

> "The belt of granitic soils of Southern Queensland, adjoining the New South Wales border, approximately 50 miles in length, with a breadth of about

* "Chemistry: Soils of the Stanthorpe District."

10 miles, is situated at an elevation from 2,300 to 3,000 ft. above the sea level, and has an average annual rainfall of about 28 in.

"The country is much broken and in places covered with outcrops of granitic boulders, but all along the slopes of the ranges, between the ridges and along the creek flats, exist large areas of coarse to fine sandy granitic soils, which are eminently suited for the culture of deciduous fruits. The soils on the creeks, which are of an alluvial nature, but still granitic, contain generally a little more clay and humus, and are, besides fruit growing, particularly suited for the culture of vegetables, such as cabbages, tomatoes, potatoes, &c.

"The soils vary in their chemical composition, but are, on the whole, easy to work, are naturally drained, and retain the moisture very well.

"Some extravagant ideas about the composition of these soils exist, and the fertility is generally attributed to large amounts of potash, amounts of potash up to 16 per cent. being mentioned, but, as a matter of fact, none of the soils will contain more than 5 per cent. of potash, the bulk of which is in a most insoluble and unavailable form.

"The soils must be classed as rather deficient in available plant-foods, and their fertility, as proved by the excellent crops obtained, is chiefly due to the physical conditions, which promote a vigorous development of the root system of trees, and enable the soil to retain a large amount of moisture. There can be no doubt however, that this fertility will be gradually reduced by exhaustion of the soil unless a proper system of cultivation, combined with manuring, is practised, as more particularly the amounts of humus, nitrogen, and lime in the soil are exceedingly low."

A fairly good idea of the *average* composition of the soil will be afforded by a study of the appended analysis of a typical soil, taken from Portion 108, Parish of Stanthorpe, close to

Thulimbah Railway Station, from forest land carrying stringybark, box, peppermint, and red gum; virgin soil, flat and slightly undulating, with natural drainage.

Description of Soil in the Field	8″ deep.	Light grey sandy loam
	24″ „	Sand
	48″ „	Sand

Description of Soil after Analyses. [Soil taken to 24″ in depth and subsoil to 48″.]		Coarse Sandy Soil.	Coarse Sandy Soil.
—		Soil.	Subsoil.
Properties of the Soil.	Reaction	Neutral.	Slightly Acid
	Apparent Specific Gravity	1·53	1·55
	Weight of Soil per Acre, 12″ deep, tons	1,857	1,882
	Capacity for Water, per cent.	26·7	26·9
	Absorbed Weight per Acre, 12″ deep, tons	496	506
	Capillarity in inches after 3 hours	8	8
	6 „	9½	9
	24 „	13	12½
	48 „	14¾	15¼
Mechanical Analyses.		Per cent.	Per cent.
	Fine Gravel	27·35	18·68
	Coarse Sand	21·86	18·71
	Medium Sand	26·72	23·92
	Fine Sand	3·26	8·75
	Silt	4·16	7·78
	Fine Silt	trace	·42
	Clay	14·13	18·22
	Organic Matter and Water	2·52	3·52

Most of the soils analysed appear to show a marked deficiency in lime contents.

References to the different classes of soil produced by the weathering of the individual geological formations will be found in Chapter IV. (General Geology).

The accompanying photograph (Plate 18) gives a view of a typical orchard—viz., that of Mr. Taylor—at Ballandean.

PLATE 18.—TAYLOR'S ORCHARD, BALLANDEAN. [*Photo., L. Jobson.*
Typical Orchard Land in Granite Country.

CHAPTER VII.

SILVER SPUR MINE, TEXAS DISTRICT.

Notes on its Geology, with Suggestions as to Future Prospecting Operations.

The township of Silverspur depends entirely for its existence upon the operations of the Silver Spur Mining Company, No Liability, of which Mr. Edgar Hall is general manager and part owner. Ever since the original discovery of copper ore in 1891 this mine has suffered from its comparatively isolated position, its location being about 53 miles by road in a west-south-west direction from Stanthorpe Railway Station (*viâ* Pikedale); it is also reached by two roads from the town of Texas, the shorter direct route being about 7 miles, whilst the longer route—*viâ* Gunyan and Raleighton—over which the mail coach travels—is about 12 miles in length. Little or no traffic is now seen on the Stanthorpe road, owing to the mail coach route being altered to start from Inglewood in lieu of Stanthorpe. A few years ago a Renard road train was put into commission to carry ore from the mine to Inglewood Railway Station, but was withdrawn after trials had proved it to be unsatisfactory for the class of work required.

RECENT OPERATIONS.

As the earlier workings at Silver Spur have already been fully described in reports furnished by Messrs. Skertchly* and Ball,† of this Survey, and also in a paper read before the North of England Institute of Mining and Mechanical Engineers, by the former manager, Mr. H. G. Stokes,‡ it is not the intention of the present writer to deal with this phase of the question, but to describe the work carried out subsequent to the report made by Mr. Ball in 1904—namely, the operations conducted below the 300-ft. level.

The above short report, dealing with the Silver Spur Mine, dated Brisbane, 22nd August, 1913, was published in "The Queensland Government Mining Journal" for September, 1913.

* G.S.Q. Publication No. 120.
† G.S.Q. Publication No. 191,
‡ "Ore Deposits of Silverspur," by H. G. Stokes, 1899.

400-ft. Level.—Ore was cut between 70 and 80 ft. south of the main shaft and stoped upwards to nearly the 300-ft. level, the nature of the material worked being mainly argentiferous galena with a small amount of zinc. A diamond drill hole was put in in a southerly direction from the lode from the main south drive; a remarkable feature about this borehole is that it is an outlet for a strong flow of water, and has been found to drain the water met with at the end of the south pass. Short drill holes through "formation" were put in at the southern end of the lode in about the same direction as the previous drive, but nothing of value appears to have been met with. A drill hole was also put in from the platt on the northern side of the shaft for a distance of nearly 100 ft. northerly, passing through a "formation" at a distance of 23 ft. in; a drive was then put in to test this portion, but, although some driving easterly on it and also westerly from the crosscut was carried out, nothing of value was found. Other short drill holes were put in easterly at this level, but failed to reveal the existence of pay ore. In sinking the No. 1 winze some seams of copper pyrites were seen.

500-ft. Level.—The main east drive was put in from the shaft in "formation," and a crosscut put in at a point 10 ft. from the end of the drive. This crosscut struck good ore at 15 ft. from the drive, which ore was then followed westerly for a short distance. The ore continues along the south-south-west crosscut to the end, where a slide is encountered. This slide is well seen in the ore-body at the 400-ft. level, where no apparent displacement has been brought about, though the surface of the ore is much polished and shows signs of a certain amount of crushing; the slide plane is extremely steep, and, judging by the position at which it emerges in the 500-ft. level workings, must maintain its angle of dip. At the end of the south-south-west crosscut at the bottom level a good bunch of ore was met with on the slide, but in my opinion the occurrence is merely accidental and has no bearing on the genesis of the ore-body itself, the slide having been induced at a period subsequent to the ore deposition, although, of course, it is possible a secondary enrichment may have occurred, though there is no apparent evidence of such having occurred here. On the western side of this crosscut some fairly good zinc ore was passed through in prospecting drill holes, but in the immediate vicinity of the slide abovementioned the zincy ore changes over to the eastern side of the level. Small bands of ore show along the drive in the roof and also occur underfoot. A prospecting drill hole for about 25 ft. south from the east side of the south-south crosscut passed through hard

rock; a further hole was also drilled from the south side of the shaft in a south-easterly direction to the crosscut above referred to, showing a little lead and zinc (concentrating) ore. Numerous quartz veins occur through the country rock at the platt at this bottom level, carrying insignificant silver values. It is of interest to note that the hard country rock itself pierced by the main shaft yields assays up to 2 oz. of silver per ton.

GEOLOGY, ETC.

The ore deposits here consist of more or less isolated lenses of sulphides (mainly argentiferous lead-zinc ores with a small amount of copper) occurring in sedimentary rocks of Permo-Carboniferous age. These sediments consist of dark-grey clay slates, conglomerates, limestones, schists, and volcanic tuffs and breccias. The tuffs, in my opinion, are by far the most abundant rocks of the series in this district, especially in the area in the immediate vicinity and including the Silver Spur Mine itself. In numerous spots throughout the district boulders of rocks—*e.g.*, granite, diorite, quartzite, &c.—can be seen embedded in the tuffs and shales, one large boulder of granite having been actually met with below the 200-ft. level in the mine workings. Mr. Ball * describes a granite pebble 3 in. in diameter found in 1903 in the ore between the 200 and 300 ft. levels in the No. 3 ore-body, consisting of white quartz, biotite, pink felspar, and pinite. Numerous granite etc., pebbles, and boulders can be seen embedded in the tuffs and shales on the track up to White's Hill. They consist of material carried by the agency of ice or floating trees, or may even represent volcanic *ejectamenta* in some instances. Limestone outcrops occur at two well-known localities in the district—viz., 6 miles north of the township of Silverspur and at Hughes's selection, 4 miles east of the town, whilst a useful deposit of ironstone flux occurs close to the first-mentioned limestone deposit. An analysis of this iron ore, quoted in Mr. Ball's report, gave the accompanying results:—

	Per cent.
Ferric oxide (Fe_2O_3)	85·22 *i.e.*, Fe = 59·66 %
Manganese oxide (MnO_2) &c.	1·69
Alumina (Al_2O_3)	5·50
Silica (SiO_2)	4·94
Water (H_2O)	2·65
	100·00

This sample was an average of a 12-ton lot. Analyst, Mr. Leon Meston.

Regarding the occurrence of the ore-bodies themselves I am of opinion that they are identical in origin with those of the

* G.S.Q. Publication No. 191, p. 28.

Western Australian goldfields—namely, nearly isolated lenses contained within a zone of crushing and shearing, the individual lenses being disposed *en echelon* at an angle across the main line of crushing. The strike of the shear zone is about north-west, whilst that of the lenses of ore contained within this zone is usually 8 degrees north of east. The opinion held by previous observers has been that the ore-bodies were formed along a well-marked line of faulting known locally as Stokes's Fault, this feature having been determined by Mr. Stokes, the former mine manager. After a careful examination of both the surface and also the underground workings, I am convinced that this fault line represents in reality the eastern edge of a crushed zone, the western edge having not yet been reached in any of the workings. While admitting the fact that some of the ore-bodies have been discovered by driving along the fault plane, I am strongly of opinion that such discoveries have been fortuitous, and that had a similar amount of prospecting been carried out *across* the shear zone ore-bodies would have been met with as frequently as was the case when the drives were put in *along* its eastern edge. There is no reason whatever for assuming that further lenses of ore will not be met with in depth or that such lenses when found will be of different composition and assay values to those already worked. It is remarkable how high the original silver values are in the ore, some of the richest ores met with hitherto not having come within the zone of oxidation or secondary enrichment; the fact that these high values are being maintained in depth augurs well for the further life of this already relatively long-lived mine.

SUGGESTIONS AS TO FUTURE PROSPECTING OPERATIONS.

As the essential reason for my having been instructed to examine this mine was to afford any information possible to the management as to the nature and extent of any ore-bodies in sight, and also to advise as to the best directions in which to prospect for further ore-bodies, I have given most attention to this subject, and append herewith a list of the prospecting operations within the mine of which the limited resources of the company might permit, and which, in my opinion, are likely to yield successful results:—

1. Diamond drills to be put in at intervals along the main south drive at the 400-ft. level in a north-westerly direction.

2. Drill holes to be put in from some point near the southern end of the south-south-west crosscut at the bottom (500-ft.) level in a direction approximately south-east in order to prospect for the lode channel from which the water is escaping in the drill hole at the 400-ft. level, referred to previously.
3. Sink a winze on the ore-body seen underfoot at the 500-ft. level at some convenient point about midway along the south-south-west crosscut.
4. Sink the main shaft at least a further 100 ft. and prospect with diamond drills from that depth in north-west and south-east directions.
5. Diamond drill from the southern end of the 90-ft. level to test the country under the calciner.
6. Drill a hole from the southern end of the 150-ft. level (No. 1 lode) towards the No. 4 shaft (*i.e.*, parallel to the main "Stokes's" fault.
7. Drill holes at right angles to the ore-body from the southern end of the 60-ft. level in No. 4 shaft in a northerly direction, one hole horizontally and a second at an angle thereto.

METALLURGY.

The two processes for the recovery of the metals now lost in the slags are those of the International Metal Company, of Hamburg, and of Messrs. Schmidt and Desgraz, of Hanover. Both processes involve the recovery of the zinc as crude zinc oxide and of the other metals as matte or metal. I am informed by Mr. Hall that both processes have been at work on a commercial scale, that of the International Metal Company at Oker, in the Harz Mountains, for about four years. The International Metal Company propose to use 15 per cent. of crude ore in the slag treatment, and would produce zinc oxide and matte. They count on a profit of about £26,000 from the treatment of 20,000 tons of slag and 3,000 tons of crude ore, the price being reckoned at the average quotation for the metals treated.

The other process—namely, that of Messrs. Schmidt and Desgraz—would produce zinc oxide, matte, and crude lead bullion, and the inventors claim that 60 per cent. of the lead, 90 per cent. of the zinc, and 75 per cent. of the silver contents of the slag could be obtained as saleable products. By treatment of the ore by their process they consider that 80 per cent. of the lead, 85 per cent. of the copper, and 90 per cent. of the zinc,

silver, and gold would be obtained. Their estimates show about £1 per ton profit from the slag and about £3 10s. per ton profit from the crude ore, taking the average quotation for metals as a basis.

I am informed that a parcel of ore was treated at Broken Hill by Horwood's Oil Flotation Process, and the test is stated to have indicated that a satisfactory metallurgical treatment can be reckoned on from this method.

In the case of Schmidt and Desgraz's process I understand from Mr. Hall that the metallurgical treatment is as follows:— The ore is ground fine and then roasted down to 2 per cent of sulphur; the roasted ore is then mixed with lime and powdered coal and made into briquettes. These briquettes are fed into one end of a gas-fired reverbatory furnace, there being a slight *plus* pressure in the furnace. The briquettes are fed at one end of the furnace behind the gas entrances, hence there is a very slight movement of the gases at the end when they are fed in. As these soften, and before they melt, the lead is reduced and sinks down under the covering of slag in the body of the furnace, and hence is protected from further volatilisation by the intense heat required to slag the remaining products. As the briquettes melt completely, the copper and a small amount of the sulphur form a matte which also sinks below the slag. The matte and lead are tapped off at intervals. The slag is run out of the furnace into a second compartment of the same furnace also heated by gas, and in this second compartment it is rabelled with a mixture of quicklime and coal dust when melted, when the remainder of the zinc is evolved. In about two hours the whole of the zinc in the slag is reduced to 2 per cent. The slag is then run off and a further charge from the first compartment is run in. The zinc is saved in bag-houses.

The average value of the matte obtained during the past two decades is £96 per ton, the matte being made at one operation of smelting. The average value is, however, now much higher owing to the enhanced values of the metals won as compared with that obtained in past years. The matte has previously averaged about 650 oz. of silver per ton, but during the present year (1913) it is expected to carry about 1,000 oz. per ton in consequence of the ore treated assaying a higher amount of copper than heretofore, and therefore yielding up a greater amount of its silver values in the smelting operations. Of course, in years when the copper contents were relatively low, the silver values were partly carried into the slag, and therefore cannot be said to be lost, awaiting as it does the metallurgical treatment of the

slag. The highest grade of matte (reckoning the silver contents) obtained yielded 1,096 oz. per ton. It is of interest to record that in 1910, owing to the gold ore met with on the 400-ft. level, the matte yielded an average of 6 oz. of that metal per ton throughout the year, or a total of £3,000 of gold. The gold yield at present is, however, nearly negligible, the returns furnished for the quarter ending 30th June, 1913, indicating that the 435 tons of ore treated yielded only 9 oz. of gold, of an estimated value of £36. Incidentally it may be remarked that the yield from the metals in the above ore was as follows:—

	£
Silver—5,100 oz., valued at	613
Copper—2 tons, ,, ...	109
Gold—9 oz. ,, ...	36
Lead—2½ tons ,, ...	37
Total	£795

This gives an average value of the ore of approximately £1 16s. 4d. per ton. The extremely low tonnage is accounted for by a prolonged drought followed by excessive rainfall during the quarter, having the effect of greatly impeding the work of smelting. It is worthy of note that the experience of the management here points to the fact that the old-fashioned open air roasting process is more effective than the complicated and expensive method of calcining, at least as regards the ores met with at Silver Spur.

During the year 1911 an average assay of the ore smelted throughout the year was as under:—

Zinc	23 per cent.
Copper	1·25 ,,
Lead	12 ,,
Gold	1½ dwt. per ton
Silver	26 oz. ,,
Sulphur	up to 29 per cent.

At the 300-ft. level there is a large mass of zinc ore assaying up to 38 per cent. of zinc, and carrying in addition 11 per cent. of lead and 15 oz. of silver per ton.

After the matte has been obtained, the slag is said to still contain the following average metal quantities:—

Zinc oxide	26 per cent.
Lead oxide	5·2 ,,
Silver	5·2 oz. per ton
Gold (extractable)	8d worth per ton
Copper (extractable)	2s. 3d. ,, ,,

It will thus be seen that the immense heap of metal-bearing slag at this mine, representing the accumulation of material ever since the mine's inception, constitutes a splendid asset if only

it can be successfully handled metallurgically. The process known as Schmidt and Desgraz's might well be expected to prove a satisfactory solution of the problem, seeing that it is in reality only an extension of the process now in actual operation at the mine. As the present metallurgical practice here has been exhaustively described in Mr. Ball's paper above referred to, it is not considered necessary to again describe that process, but merely to direct to it the attention of those interested in the subject.

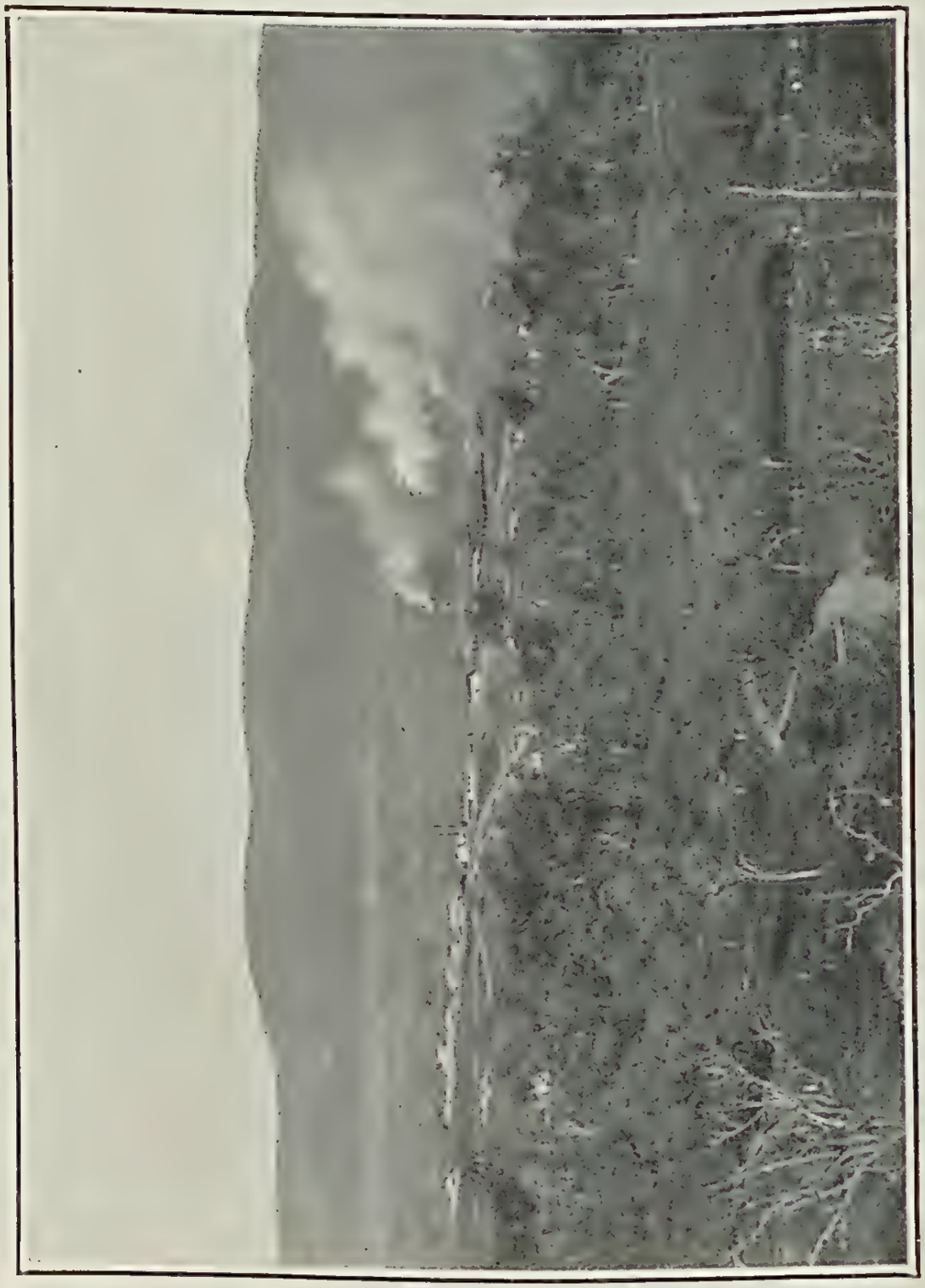


Plate No. 19.—General View of Township and Surrounding District, Silverspur.

The accompanying views of the township and mine were kindly taken for this report by Mr. C. O. Jack, assayer at the Silver Spur Mine.

PLATE No. 20.—PORTION OF TOWNSHIP, SILVERSPUR.

PLATE No. 21.—OPEN-AIR ROASTING IN KILNS, SILVER SPUR MINE, SILVERSPUR. *Photos: C. O. Jack*

PLATE No. 22.—SILVER SPUR MINE. [*Photo., C. O. Jack.*

SHOWING DEPLETION OF SURROUNDING COUNTRY OF FIREWOOD, SILVERSPUR.

[*Photo., C. O. Jack.*

PLATE No. 23.—DAM FOR BOILER SUPPLY PURPOSES, SILVER SPUR MINE, SILVERSPUR.

CHAPTER VIII.

STATISTICS.

The total value of the tin ore produced in Queensland during the period that has elapsed since the inception of mining operations up to the 31st December, 1912, represents 7·89 per cent. of the grand total value of all the minerals won during that period. The relative importance of the Stanthorpe district as a contributor to the State's production of tin-ore can be seen on reference to the accompanying statistical table showing the actual quantity of the mineral won since the discovery of the field in the year 1872 up to the end of the last year (1912), for which returns are at present (September, 1913) available. This information has been compiled with great care from every available *official* source by Mr. Russell Dixon, of the Geological Survey Office, for inclusion in the "Mineral Index of Queensland,"* by Mr. B. Dunstan, Government Geologist.†

Annual Yield of Tin Ore in the Stanthorpe District, 1872 to 1912, inclusive.

Year.	Tin Ore. Tons (2,240 lb.)	Value.	Year.	Tin Ore. Tons (2,240 lb.)	Value.
		£			£
1872 ..	1,407	109,816	1893 ..	334	10,284
1873 ..	8,938	606,184	1894 ..	172	6,055
1874 ..	5,702	358,550	1895 ..	93	3,160
1875 ..	4,475	237,879	1896 ..	96	3,072
1876 ..	4,315	187,201	1897 ..	53	1,666
1877 ..	3,335	133,432	1898 ..	90	3,600
1878 ..	2,849	88,366	1899 ..	73	4,531
1879 ..	2,745·5	115,131	1900 ..	64	4,349
1880 ..	2,653·5	135,237	1901 ..	81	4,860
1881 ..	2,272·5	146,359	1902 ..	112	7,728
1882 ..	2,451	197,504	1903 ..	253	18,259
1883 ..	817	40,233	1904 ..	385	29,954
1884 ..	934	41,096	1905 ..	334	29,589
1885 ..	503	25,150	1906 ..	310·5	34,630
1886 ..	430	24,940	1907 ..	324	32,784
1887 ..	356	22,072	1908 ..	437	35,356
1888 ..	414	26,910	1909 ..	115	9,265
1889 ..	310·5	16,146	1910 ..	128·25	12,360
1890 ..	277	14,404	1911 ..	136.00	15,199
1891 ..	244	12,688	1912 ..	166·25	21,428
1892 ..	246	13,043			
Total ..			.. ..	49,431·50	2,840,470

* G.S.Q. Publication No. 241.

† It will be noticed that there is a greater *State* tonnage shown in these figures than those given in the Annual Reports of the Department of Mines; I understand from Mr. Dixon that the discrepancy is due to the omission from the lastnamed reports of the official returns for tin ore won from the Cannibal Creek and Granite Creek alluvial tin workings on the Palmer Goldfield during the years 1879, 1880, 1881, and 1882 (also given in "The Mineral Wealth of Queensland," by R. L. Jack, late Government Geologist, page 49, published in 1888, being G.S.Q. Publication No. 48).

The appended figures, taken from the "Mineral Index of Queensland," indicate *inter-alia* the relative position of this district as a mineral producer from the fact that the value of the tin ore won in the Stanthorpe district represents (*a*) 36·72 per cent. of the total production of that mineral in Queensland, and (*b*) that the total mineral production of this district constitutes 3.04 per cent. of the value of the total production of all minerals won in this State up to the end of the year 1912.*

Mineral Summary of the Stanthorpe District to 31st December, 1912.

Mineral.	Estimated Total Yield.	Estimated Value.	Percentage of the Total State Production.
		£	
Copper	1,144·75 tons	70,318	0·58
Silver	2,061,345 oz.	234,361	15·27
Wolfram	2 tons	188	0 03
Lead	1,044·75 tons	13,926	2·65
Molybdenite	...	4	...
Limestone	14,190 tons	3,493	1·63
Ironstone	806 tons	378	0 31
Tin Ore	49,431·5 tons	2,840,470	36·72

Total £3,163,138 worth, representing 3·04 per cent. of the value of the total Queensland mineral production.

The following table gives a detailed statement of the annual production of Silver and Lead during the period that has elapsed between the commencement of mining operations for those metals and the end of the year 1912:—

Table showing Estimated Annual Production of Silver and Lead in the Stanthorpe District to 31st December, 1912.

Year.	Silver. Yield (in Oz.)	Lead Yield (in Tons.)	Year.	Silver. Yield (in Oz.)	Lead. Yield (in Tons.)
1892 ..	280	..	1903 ..	85,460	45·00
1893 ..	17,128	..	1904 ..	122,385	58·00
1894 ..	85,067	..	1905 ..	140,882	74·00
1895 ..	106,940	..	1906 ..	170,146	116·00
1896 ..	122,421	..	1907 ..	157,662	95·50
1897 ..	113,822	..	1908 ..	177,632	107·00
1898 ..	60,000	..	1909 ..	110,316	69·25
1899 ..	75,698	..	1910 ..	101,787	51·00
1900 ..	68,914	63·00	1911 ..	125,544	81·50
1901 ..	75,055	200·00	1912 ..	69,386	35·50
1902 ..	74,820	49·00			
		Total ..	.. ..	2,061,315	1,044·75

* The Annual Report of the Department of Mines for 1912 gives the total Queensland production of tin ore as being 131,432$\frac{19}{20}$ tons, of an estimated value of £8,110,704, as against the yield of 134,592·75 tons, valued at £8,199,391, as given in the "Mineral Index of Queensland."

During the year 1912 the number of miners engaged in mining operations for various minerals throughout this field was as follows:—

Gold (quartz)	2
Silver and Lead	54
Tin	108
Copper	9
Total	173

It is confidently expected, however, that the more active operations now (1913) in progress will absorb a greater number of tin miners than the relatively limited number above stated. The foreshadowed commencement of smelting operations on a much larger scale at Silverspur will also doubtless necessitate the employment of many additional hands in the future. Dredging operations continue to account for the major part of the men directly employed in tin-ore mining, besides furnishing much work for those engaged in attendant industries—*e.g.*, wood-carting, &c.

The revenue collected by the Department of Mines for the year 1912 from this district amounted to the sum of £799 11s. 9d., being an increase of £269 15s. 4d. on the figures for the previous year (1911). This increase is attributable in large part to the greater activity now being displayed in lode-tin mining at Red Rock, Carpenter's Gully, Stanton, &c.

Seeing that the successful mining in the future of the already greatly depleted supplies of tin ore in this district is intimately bound up with the all-important question of whether this substance will maintain its present relatively high price, it is thought that the appended information on the subject of the tin-production throughout the world will prove of value to those who are interested in this question financially.

The latest most authoritative statement of the position of tin in the markets of the world at present available to me is that given in the 18th Annual Issue (1902-1911), compiled by the Metallbank und Metallurgische Gesellschaft, Frankfort on Main;

published in July, 1912. From this publication the following summary has been extracted:—

"The world's production of raw tin increased in 1911 by 2,500 tons, or 2·2 per cent. over that of the preceding year. In 1910, the increase as compared with 1909 was 1,800 tons, or 1·6 per cent. The changes in the quantities respectively furnished by the most important producing territories were as significant as the total increase. The shipments from the Straits, as before, take the lead, the total for 1911 being 57,900 tons, as compared with 57,500 tons in 1910. In 1911, therefore, these shipments constituted 49 per cent. of the world's output. Whilst in 1909 and 1910 Straits shipments showed a falling off, there was an increase, though only of 400 tons, in 1911, the higher prices prevailing last year having stimulated output in the Straits by encouraging an influx of Chinese labour.

"As to the deposits of tin ore in parts of the far East, we must leave those of Siam out of account, as we have no reliable data of the extent of the output therefrom, but we have in our present Statistics been able for the first time to include estimates regarding China.

"China's principal tin ore deposits are situated in the province of Yunnan, especially in the neighbourhood of Mengtsz. According to the Maritime Customs Export Statistics, China exported in 1910 6,500 tons of tin, and in 1911 6,000 tons, of which quantities 6,200 tons in 1910 and 5,800 tons in 1911 came *viâ* Mengtsz. China, therefore, in 1911 contributed about 5 per cent. of the world's total production. Part of this Chinese tin goes from Hong Kong back into China, to fill the Chinese demand, whilst part is exported to Europe and the United States.

"In *Australia* the output of tin declined from 5,500 tons in 1910 to 5,150 tons, or 4·4 *per cent. of the world's*

output, in 1911. Since 1907, when Australia's production reached its top limit of 7,400 tons, there has been a steady falling-off in the output of tin.

"European smelters, apart from Cornwall's mine output, have, as previously, been in the main dependent on supplies of tin ore from oversea. Great Britain produced from Cornish ore in 1911 about 4,500 tons, as compared with 4,874 tons in the preceding year. In addition thereto, Great Britain's output of tin from imported ores last year amounted to 13,850 tons, as against 13,055 tons in 1910. In 1911, therefore, English smelters produced in all 15·5 per cent. of the world's output. In Germany, 12,400 tons, or 10·5 per cent. of the world's output, was produced last year, or roughly, 1,000 tons more than in the preceding year. Of this output only a small proportion was derived from the de-tinning of tinplate scrap, by far the greater part having been produced from imported ore.

"The bulk of the tin ore smelted in Europe came, as before, from Bolivia. In the first six months of last year, Bolivia's exports of tin ore amounted to 19,052 tons of ore, containing 11,400 tons of tin, whilst for the whole of 1911, the 'Mining Journal' gives the quantity of tin contained in the ore exported as 22,200 tons, or 18·8 per cent. of the world's output. In 1910 Bolivia exported 38,500 tons of tin ore, containing 23,100 tons of tin, or 20 per cent. of the world's total. Metallic tin is only produced in Bolivia in very small quantities, which are almost exclusively shipped to Great Britain. Germany imported in 1911 18,000 tons of tin ore, of which 95 per cent. came from Bolivia; 74·4 per cent. of the imports of tin ore into Great Britain also came from Bolivia.

"Africa's importance as a source of ore supply continues to grow. South Africa exported, in 1911, 3,500 tons of tin ore to Great Britain, as compared with 3,450

tons in the previous year. Nigeria sent 1,400 tons of tin ore to Great Britain in 1911, as compared with 700 tons in 1910. A further expansion of this output is expected in the future, especially as a section of the railway in course of construction to the tin-mining district has been opened.

"The world's consumption of tin in the year 1911 amounted to 117,400 tons, as compared with 121,300 tons in the preceding year. Notwithstanding this decline of 3,900 tons, or 3·2 per cent., the consumption in 1911 was greater than in any year prior to 1910.

"A very large proportion of the tin consumed is used in the production of tinplates, which is principally carried on in Great Britain (Wales) and in the United States.

"Thanks to the continuous and active demand for tin, and to the favourable statistical position, the prices of tin remained very high in 1911; and also during the first six months of 1912, as appears from the following monthly average prices (for 1912)"*:—

	£	*s.*	*d.*
January	191	14	0
February	195	4	10
March	192	15	0
April	200	8	3
May	209	6	1
June	205	18	9

From the same publication the accompanying tables of statistics have been taken, showing, respectively—

"(*a*) The monthly and yearly average prices for foreign tin on the London Metal Exchange, from 1901 to 1911 inclusive; and

"(*b*) A comparative statement showing the world's annual production and consumption of raw tin, from 1902 to 1911 inclusive."

* Advance figures.

Table A. **Monthly and Yearly Average Prices for Foreign Tin on the London Metal Exchange.**

(In £ per English ton.)

Month.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
January	120 9 10	105 6 5	127 12 6	130 10 4	131 5 11	164 11 10	199 4 0	123 9 0	127 7 3	148 3 6	187 17 11
February	122 6 11	114 4 9	133 8 1	125 13 6	131 3 6	166 0 10	191 18 9	128 14 1	127 15 3	149 13 0	189 12 10
March	116 15 6	115 10 6	137 0 6	126 9 8	134 17 2	166 1 2	188 17 6	137 19 8	130 6 7	147 4 11	182 12 4
April	116 3 0	125 14 2	136 19 2	127 5 1	140 11 8	176 14 5	187 1 2	143 12 10	133 8 3	149 19 3	193 0 10
May	123 13 0	134 13 10	133 12 0	125 7 2	136 11 8	192 6 4	191 1 10	135 11 6	131 16 10	150 1 8	197 15 4
June	129 16 11	129 12 10	127 11 0	119 11 1	138 3 6	178 0 7	187 10 11	127 12 2	133 4 0	148 13 1	207 7 9
July	127 19 9	127 3 2	125 1 7	119 18 6	144 6 8	170 12 5	188 0 2	131 6 10	131 19 1	149 2 1	193 2 0
August	116 1 7	126 10 0	127 16 10	122 5 9	150 5 6	180 19 11	170 5 9	134 16 2	135 18 3	155 8 2	190 9 7
September	114 10 6	121 10 7	120 9 6	126 7 7	146 11 9	184 15 3	166 6 6	131 6 8	137 14 6	160 8 7	180 16 11
October	113 1 5	117 11 3	115 17 1	130 11 6	148 3 6	195 15 11	146 7 7	133 8 8	138 13 2	164 4 9	187 2 9
November	114 0 7	115 2 3	116 13 9	133 0 5	152 5 3	195 15 10	138 8 8	137 8 3	140 0 3	166 18 0	194 19 4
December	108 17 10	115 13 5	125 15 0	133 15 6	162 14 3	195 19 9	125 10 4	132 4 7	149 2 3	173 17 3	203 7 2
Yearly Average	118 12 8	120 14 5	127 6 5	126 14 8	143 1 8	180 12 11	172 12 9	133 2 6	134 15 6	155 6 2	192 7 0¾

Table B. **Comparative Statement showing the World's Annual Production and Consumption of Raw Tin.**

(In Metric Tons.)

Year.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.
Production	96,700	100,500	103,100	102,400	104,400	102,400	113,300	113,900	115,700	118,200
Consumption	99,700	101,600	101,100	104,100	107,800	105,200	100,900	109,100	121,300	117,400

CHAPTER IX.

FUTURE PROSPECTS OF THE FIELD.

After a consideration of the aforegoing, the question naturally arises as to what are the future prospects from a mining standpoint of the area mapped, and what suggestions can be offered as regards possible future search operations for new finds in this district.

As regards the latter, it becomes, of course, a matter of difficulty to suggest sites for prospecting for new alluvial claims, seeing that mining has been carried on here continuously for over forty years, but, in view of the fact that the relative importance of the fine-grained acid ("Sandy") granite as the main producer of the tinstone in the first instance has been overlooked in the past, I would strongly recommend prospectors to pay particular attention to the area covered by this formation lying to the north and east of Stanthorpe (shown on the geological map of Stanthorpe issued with this report). The heads of such gullies —*e.g.*, Doctor's, Hardy's, Funker's, Kettle Swamp, Blue Mountain, &c.—as traverse this rock outcrop should be carefully searched for both alluvial tin, tin, wolfram, and molybdenite veins. The positions most favourable for the occurrence of lodes are those bordering the contact between this rock and the intruded "Stanthorpe" (coarse acid) granite and the slates, and more particularly where numerous veins of quartz, pegmatite, aplite, greisen, and porphyry are observable along the contact zone. As, however, in my opinion, in common with previous observers, the tinstone found in the alluvials has not been derived from large tin lodes, but rather from the denudation of countless millions of tiny veins and also in part from the original granite rocks themselves, I am not hopeful of payable lodes being found in the Stanthorpe district, any occurrences being probably in the nature of more or less isolated rich "bungs."

In the case of the Ballandean area, the lode tin-mining will probably be found to be limited in the main to the arsenical pyrites lodes in slate at Sundown and the contact veins along the margin of the "Sandy" granite and slate at Red Rock, Carpenter's Gully, and Stanton. The *whole* of the contact zone, say a couple of chains into each formation from the actual junction line, should be carefully prospected for tin, wolfram, and molybdenite, whilst loaming will probably indicate the existence of a wider extent of "surface" tin along the hillsides at the contact than that at present known to exist at the Beehive property. The old Kilminster area, near the Severn River—including the Queen, Lord Nolan, &c., mines—deserves more careful prospecting for rich patches of tin and wolfram, as also

does the ridge of "Sandy" granite in the neighbourhood of Cannon's old shaft. In my opinion, the Sundown tin lode is the most promising of any of the lode formations seen during my examination of the Stanthorpe district, and well warrants the erection of a battery to treat the material already available and in sight.

The dredging now carried on in the Stanthorpe district being mainly confined to the treatment of previously worked alluvial flats on freehold property by private syndicates, it is not an easy matter to arrive at any conclusion as to whether these operations are proving as satisfactory from an investor's point of view as is thought by some to be the case. Taking into consideration the comparatively low average yields per cubic yard as given in the quarterly returns furnished by the dredge managers, and also the heavy charges for firewood, wages, &c., the initial cost of the plants, and, in many cases of the actual purchase of the freeholds themselves, it is certainly a fortunate circumstance for those financially interested in these ventures that the high price ruling for tin has been maintained for some months past, and gives every indication of continuing so to do for a long time to come. The nature of the "bottom," the composition of the overburden, the presence in many cases of hard bars across the stream channels, the frequently limited extent of the stanniferous material, &c., generally fully justifies the adoption of small portable plants. However, the areas treated at the old Brisbane claim and that now being treated at Allison's No. 1 Sugarloaf dredging claim, Sugarloaf Creek, are well suited to barge plants. After a considerable experience gained on the New England (N.S.W.) tinfields and elsewhere with dredging plants, I am of opinion that small cheap plants of the portable variety will ultimately prove the most serviceable as well as the best paying proposition under the particular conditions obtaining at Stanthorpe.

The pumping out of deep holes along the Severn and Broadwater, as described elsewhere in this report, will be frequently found remunerative, but care should first be exercised to learn if any alluvial material now remains in these holes, for in the case of several tried by myself there was not a trace of alluvium left, owing to the scouring action of flood-waters.

The splendid cool climate, elevated situation, accessibility to both Brisbane and Sydney, scenery, and the suitability of the soil for orchards and gardens, combine to make this region an ideal resort for tourists and those who wish to live comfortably in a mild climate after a lengthy sojourn in the tropical portions of the State.

Brisbane, October, 1913.

APPENDIX I.

MINERAL LEASES.

The accompanying information concerning the leases in this district is issued for general information:—

LIST OF MINERAL LEASES IN FORCE, STANTHORPE MINERAL FIELD, AUGUST, 1913.*

Number.	Holder.	Locality.	Area.
			Acres.
54	The Silver Spur Mining Co. ..	Silver Spur	20
68	,, ,, ,, ..	,, ...	10
73	,, ,, ,, ..	,, ...	10
74	,, ,, ,, ..	,, ...	5
80	,, ,, ,, ..	,, ...	4
85/87/102/106/107	Richard Old	Warroo United Leases	64
99	Henry Benjamin	Severn River ..	10
114	Horsley Clark	Redrock	10
120	Claude Musson	Carpenter's Gully ..	25
121	William Lynam, junr.	Redrock	20
122	Eli Marstella	,, ...	10
123	,, ...	,, ...	9-3-4
124	,, ...	,, ...	2-0-23
125	,, ...	,, ...	9-3-28
126	Horsley Clark	Redrock Creek ..	10
127	Henry John Collins	,, ,, ..	5-0-0
129	Henry Benjamin	,, ,, ..	26-0-0
130	Thos. Curtain and Robert Francis Pettiford	Carpenter's Gully ..	10-0-0
131	Eli Marstella	Redrock and Stanton	10-0-0
132	Arthur Morry	near Gore R. Station	5-0-16
133	,, ,, ...	,, ,, ,, ..	4-3-24
134	,, ,, ...	,, ,, ,, ..	4-3-24
135	,, ,, ...	,, ,, ,, ..	2-3-8
137	,, ,, ...	,, ,, ,, ..	19-0-0
138	,, ,, ...	,, ,, ,, ..	7-2-32
139	James Edward Long	Carpenter's Gully ..	25-0-0
140	John Conrad Segnizerling and Ed. Gillott	Gore	3-0-0
141	Jas. Hamilton Carmichael and Jno. Geo. McGregor	,, ...	4-0-0
142	Henry Benjamin	Redrock	10-0-0
143	,, ,, ...	,, ...	6-2-0
144	John Schaefer	,, ...	10-0-0
145	John Gilchrist and Alex. Johnston	Carpenter's Gully ..	30-0-0
148	Horsley Clark	,, ,, ..	9-0-0
	Gold Mining Lease.		
4	Joseph McLucas	Pikedale Goldfield, McLucas Gold Mine	20-0-0

* Information kindly furnished by Mr. Warden Kennedy, Stanthorpe.

APPENDIX II.

TESTING SAMPLES FOR PROSPECTORS.

Samples of ore are constantly being received by the Geological Survey Office from miners and others who desire to know the commercial value of the minerals they contain, but the conditions to be fulfilled are not generally observed, neither are the samples, except in rare instances, properly prepared for assay.

Minerals and rock specimens requiring simple classification are examined unconditionally, but a stipulation is made that those who require fire assays or chemical analyses of minerals should be prospectors, and also that the samples are from localities which are not well-defined centres of mining development, but rather where the country is being developed after having been abandoned, or where previously no prospecting work has been undertaken.

These conditions are objected to by many, but our desire is simply to assist in the work of mineral discovery, and this object is attained by attending to the requirements of the prospector. When assays are made for buyers and sellers of parcels of ore, or for the purpose of company flotation, the schedule charges are insisted upon. The privilege of obtaining free assays from the Department is no doubt abused to some extent, but this evil might be tolerated in view of the good results which accrue in so many other ways.

There is another condition which most prospectors take exception to at first, but which, nevertheless, is quite in reason—that is, making known the locality from which the samples were obtained. An average of about 10 per cent. of the samples tested give returns which show that the minerals they contain are in payable quantities, the 90 per cent. being of no present commercial value. Of the latter, about 60 per cent. are not even of prospective value, the remaining 30 per cent. possibly being valuable in years to come—when facilities for mining development and for transport become better, and when some of the minerals now worthless will no doubt be found useful in some of the manufacturing industries.

It is also very important that the absolutely valueless mineral deposits—the 60 per cent.—should be recorded to indicate the localities where prospecting work has been futile. It is

now known that duplicate assays have been made of minerals from the same locality, separate parcels being sent by different individuals, each of whom, perhaps, was not aware that others had furnished similar samples to be tested. Were particulars supplied regarding the localities, this duplication of assays, and the expense incurred, would be avoided.

Another advantage resulting from the possession of this information would be in enabling advice being given to miners who wish to further prospect a mineral deposit previously examined. Miners could be given the results of previously made assays and tests of mineral deposits they propose to operate upon, if such have been made, and this might result in encouragement being given to further development, or, on the other hand, might indicate that such work would entail waste of labour and money. It has frequently happened that a party of miners, in reopening an abandoned mine, would not have started operations had they known beforehand the result of assays made for those who previously worked the mine.

The preparation of samples for assay and for mineral classification is quite simple, and should hardly need a description. Nevertheless, parcels of stone are frequently received which consist perhaps of a couple of pieces, and which cannot be considered average samples. For the *determination or classification* of any mineral species, good clean pieces are desired, and the quantity should not be too small. In the *estimation of quantities*, such as the percentage of copper or tin, or the number of ounces of gold or silver per ton, it is necessary to carefully prepare the samples. Many will break off a piece of stone from a lode and from that expect a result indicating the average yield of the whole mass, and fail to see that in such a test rich stone may be overlooked. On the other hand, the specimen might give a rich return, and will perhaps result in money being spent in developing the deposit of mineral, after which it might be found that the bulk of the stone is either barren or too poor to pay. The man who supplies the funds for carrying on operations might think the prospector had deceived him as to the quality of the stone, or both might think the stone was not properly tested in the laboratory, and put the blame on the assayer.

The better method of sampling is to take stone from all exposed places on the lode, which must then be crushed and mixed, and afterwards quartered. One quarter is then more finely crushed and again mixed and quartered, the operation being repeated until the bulk is reduced sufficiently to make a

small fine-crushed sample weighing two or three pounds. When this is not practicable, very small pieces—say, fifteen to the ounce—should be chipped off all exposed places, from which a sample is taken after finely crushing and mixing. This will give a fairly satisfactory result, although not so accurate as the former method. It would also be as well to include a large chip of the mineral as a guide to its classification.

Attention should also be given to the forwarding of *samples*. They *should have some distinguishing mark, and this should be referred to in the letter of advice*. Many samples received are without marks, which causes confusion, and the greatest care has to be exercised in identifying post-marks, or in comparing handwriting, in order to avoid samples from one individual being mistaken for those sent by another.

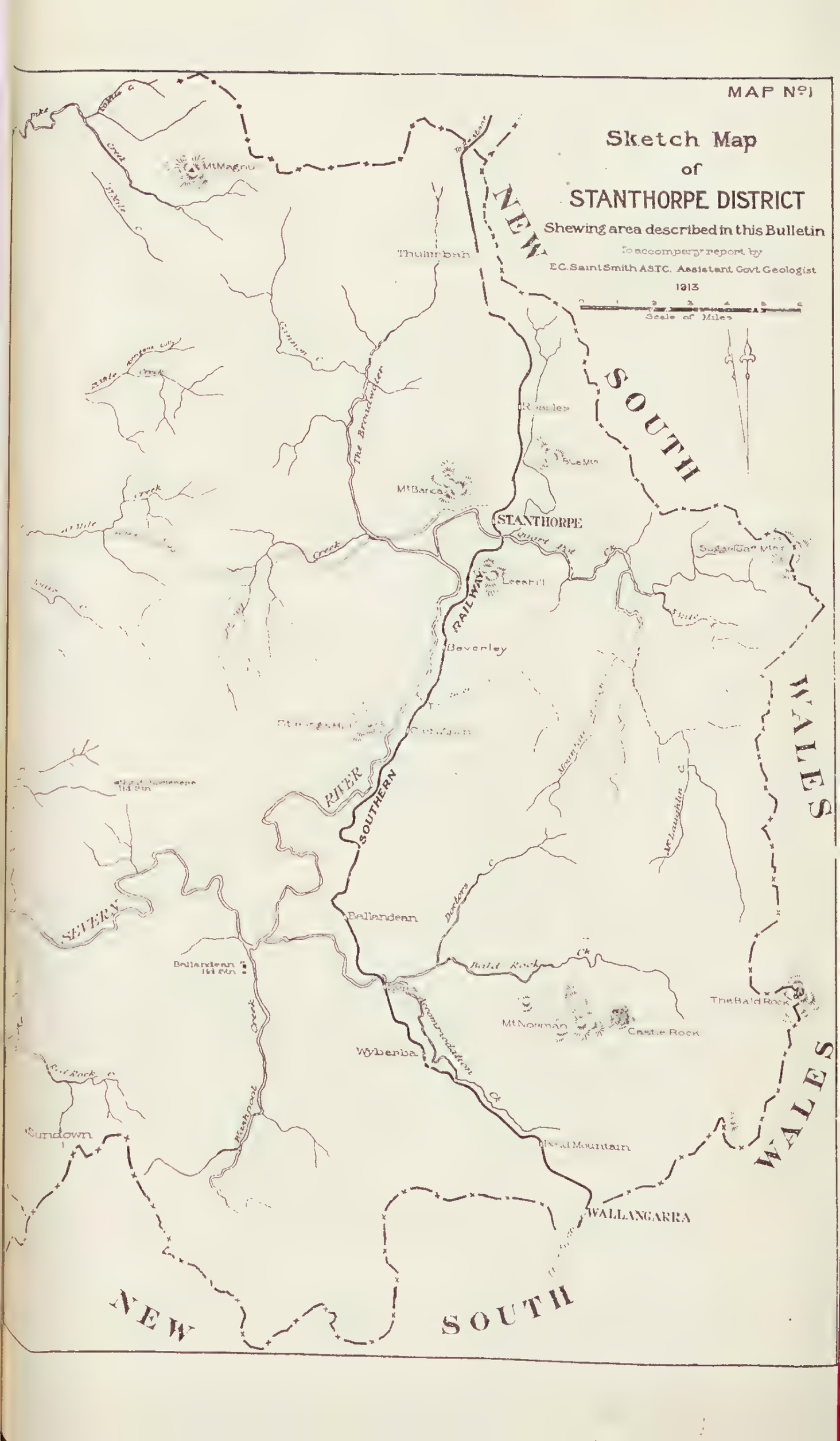
MAP 2.—Geological Sketch Map of the Stanthorpe (Queensland)-Wilson's Downfall (New South Wales) Petrographical Province.

MAP 3.—Geological Map of the neighbourhood of Stanthorpe, Ballandean, and Wallangarra.

MAP 4.—Geological Map of the Red Rock, Carpenter's Gully, &c., Stanniferous areas, Ballandean ; with some topographical features.

By Authority: ANTHONY JAMES CUMMING, Government Printer, Brisbane.

NATIONAL MUSEUM


MAP No1
Sketch Map
of
STANTHORPE DISTRICT
Shewing area described in this Bulletin
To accompany report by
E.C. Saint Smith A.S.T.C. Assistant Govt Geologist
1913
Scale of Miles
NEW SOUTH WALES
Mt Magnu
Thulimbah
Mt Barca
STANTHORPE
Leeshill
Beverley
Ballandean
Wybenba
Mt Norman
Castle Rock
The Bald Rock
Sundown
WALLANGARRA
RIVER SOUTHERN
RAILWAY
SEVERN

VICTORIA

MAP Nº 2

Geological Sketch Map

of the

STANTHORPE Q. WILSONS DOWNFALL N.S.W. PETROGRAPHICAL PROVINCE

TO ACCOMPANY REPORT BY

E.C. Saint Smith A.S.T.C. Assist. Govt. Geologist

1913

Scale of Miles 0 1 2 3 4 5

QUEENSLAND

NEW SOUTH WALES

Mt Magnus
Pikes Creek
Tenterfield
Tenterfield Creek
Tenterfield Station
Tenterfield Railway Station
Tenterfield Railway Station
Tenterfield Railway

MAP Nº 3

Geological Map

OF COUNTRY IN THE NEIGHBOURHOOD OF

STANTHORPE, BALLANDEAN & WALLANGARRA.

STANTHORPE MINERAL FIELD

TO ACCOMPANY REPORT BY

E.C. Saint-Smith, A.S.T.C., Assistant Govt Geologist

Assisted by E.F. Eberhardt.

1913

Scale of Miles

Prepared at the Department of Mines, Brisbane, Q. 1914 E.F.E. Del.

Nº 243 Geological Survey Publication.

County of Merivale

NEW SOUTH WALES

Lat 28°30'S.

Lat 28°40'S.

Lat 28°50'S.

Long 151°52'E.

Long 151°50'E.

STANTHORPE

BALLANDEAN

WALLANGARRA

BEVERLEY

GLENAPLIN

WYBERBA

THULIMBAH

Broadwater School

Stanthorpe Town Common

Camping Reserve

Racecourse Res

Police Res

Water Res

Reserve for Public Purposes

Mt Magnus

Miss Molybdenite Claim

Sandy Gully Reserve

Ballandean Recreation

Accommodation Paddock

Sugarloaf Mountain

Castle Rock

The Cavees

Blue Mountain

Mile Gates

Sundown

Carpenters Gully

Queen Mine

Mt Nolan

Chalmers Molybdenite Claim

Tin Mining

Tramway

Railway

Creek

River

Road

Reserve

Camping

Township of Stannum

For Details See Map Nº 4

GEOLOGICAL RECORD

AND

INDEX TO COLOURS AND SIGNS.

QUATERNARY AND CAINOZOIC	RECENT	Alluvia along present stream channels *(stanniferous)*	
	PLEISTOCENE (?)	High Level gravels, ferruginous cement, etc. *(stanniferous)*	
TERTIARY (?)		Diorite, lamprophyre, etc., dykes (sometimes associated with *gold, silver, lead, zinc, and copper lodes*)	Diorite &c. &c.
MESOZOIC (?)		Quartz-porphyry and aplite granite dykes and greisen veins *(tin, wolfram, and molybdenite bearing)*	
		Fine-grained acid granite (the "Sandy Granite") *(tin, wolfram, and molybdenite bearing)*	
		Coarse-grained acid granite (the "Stanthorpe Granite") (sometimes *stanniferous)*	
		Porphyritic granite (sphene bearing)	
PALÆOZOIC	Permo-Carboniferous — Upper Bowen (?)	Micro-granite (the "Blue Granite")	
	Permo-Carboniferous — Lower Bowen	Marine slates, tuffs, conglomerates, limestones, etc. ("Trap") (rarely *stanniferous*, numerous *gold, silver, lead, zinc, and copper lodes*)	
	Pre-Permo-Carboniferous	Acid grey felspar porphyry ("Trap")	
		Granulite ("Trap")	

VICTORIA.
NA.

MAP Nº 4

GEOLOGICAL RECORD

AND

INDEX TO COLOURS AND SIGNS.

MESOZOIC (?) — Fine grained acid granite ("Sandy Granite")

PALÆOZOIC { Permo-Carboniferous (Lower Bowen) } — Marine slates, tuffs, conglomerates, etc. ("Trap")

Workings

POR. 102

H.J. Collins

Mt. Lofty

Old dog proof fence

Track

Trenches ML127

Potholes

Lode

ML 126

ML129

"Stanton"

ML123

ML114

Quartz Blow

ML131

ML122

"Beehive"

ML121

ML 124

Precipitous

ML125

Red Rock Creek

Deep Gorge

Falls

831w

523w

Walk

Old Camp

Freehold

288w

290w

ML120

"Jericho"

Gully

Gorge

Cut

Deep Cut

763w

72w

Freehold

55w

Freehold

Numerous Quartz Veins and Aplite Dykes in Creek

70w

699w

576w

Opencut

Shepherds Gully

Large Quartz Blow

country

ML109

Trench

Gilchrist & Johnsons' Claim.

ML130

Cuts

Shaft

289w

71w

Freehold

Carpenters Gully

Track

829w

313w

774w

and Back Track

813w

828w

832w

To Ballandean

814w

ML 28

ML 27

Smelter

Adit

Sundown Mine

ML 24

"Sundown"

ML110

ML 108

Dyke

Dioritic

Numerous

811w

810w

809w

808w

Road

Good

POR. 103

W. Walsh

Geological Map of REDROCK and CARPENTERS GULLY STANNIFEROUS AREAS

TO ACCOMPANY REPORT BY

E.C. Saint-Smith, A.S.T.C. Assistant Govt. Geologist

Assisted by E.F. Eberhardt.

1914.

Scale of Chains

0 4 8 16 24 32 40 48

Prepared at the Mines Department Brisbane Q. E.F.E.

G.S.Q. Publication Nº 243.

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DEPARTMENT OF MINES.

Geological Survey of Queensland.

(B. Dunstan, Government Geologist.)

PUBLICATION No. 245.

THE ETHERIDGE MINERAL FIELD

(The Potentialities of the Southern Portion),

WITH

1 MAP, 5 PLANS, AND 14 PHOTOGRAPHS.

BY

LIONEL C. BALL, B.E. (Syd.),

ASSISTANT GOVERNMENT GEOLOGIST.

BRISBANE:

BY AUTHORITY: ANTHONY JAMES CUMMING, GOVERNMENT PRINTER.

1915.

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The Mineral Localities of The Etheridge Goldfield

Compiled from Official Records by L.C.B.
Topography as on Previous Maps

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Blue – Lead
Green – Copper
Red – Tungsten (W), Bismuth (Bi), Tin (Sn)

Lease
Claim
Prospecting
Protection Area

Scale of Miles
0 2 4 6 12 18 24

E T H E R I D G E

G O L D F I E L D

GREEN HILLS GOLDFIELD

GRACEMERE
NO GOLD
EVELEIGH
EVELEIGH No5
EVELEIGH No6
144° 30'
EDEN VALE No1
DAGWORTH
EDEN VALE
LUBRINA
NAMARRONG
EVELEIGH Sn
EVELEIGH No1
No4
WOMBLEALLA No5
WELCOME
FIERY
18°
LUBRINA No1
LUBRINA No2
EVELEIGH No2
BROOKLAND No1
FIXBY No2
SPRINGFIELD
ALBERT DOWNS
HUONFELS
Lane Creek
HUONFELS No2
HUONFELS No1
SHAMROCK
SHAMROCK No1
BROOKLAND No3
STONY RISES
BROOKLAND No2
ROCKVALE
ROCKVALE No1
EVELEIGH No3
EINASLEIGH
ETHERIDGE
NEWCASTLE
WOLLASTON
HUONFELS No3
GREEN HILLS No5
GEORGETOWN
BROOKLAND
ROSELLA PLAINS No2
ROSEDALE
BOX HILL No5
BOX HILL No4
GREEN HILLS No7
Dunvalloe
GEORGETOWN No1
ROSELLA PLAINS No7
ROSELLA PLAINS No3
BERDARNOCK
GREEN HILLS No9
DELANEY RIVER
ELLENDALE
GREEN HILLS No8
GREEN HILLS No10
GREEN HILLS
18° 30'
Macdonaldtown
CHARLESTON
EINASLEIGH
MOPAA
ROSELLA PLAINS No6
MAIDEN VALE
GREEN HILLS No3
CARPENTARIA
DOWNS
RED ROCK
Castleton
MAMBERRA
OAKVALE EAST
BAROOTA
GREEN HILLS
GREEN HILLS No1
KITCHENER
GREEN HILLS No11
BLACKWELL
OAKVALE
ROBERTSON
Sn
LANG
NORTH HEAD No1
WIVENHOE No2
ROBINHOOD No2
LITTLE ROBERTSON RIVER
RANGE
NORTH HEAD No2
WIVENHOE No1
NORTH HEAD No3
NORTH HEAD No4
MOSCH
GILBERT
ROBINHOOD
MOSCH No1
SHOREHAM
BAGSTOWE No2 NORTH
CHRISTMAS HILL No2
LOCHABER
SUNNYN
RELIEF
BLAND
PEPPER
OLIDS
BAGSTOWE No2
BAGSTOWE No1
Millogar
Orion
OL.
MOUNT LOOKOUT
OAK PARK
COPPERFIELD
EASTDALE
DUFFER
REDCAP
PEKIN
MICA NORTH
MICA
PERRYVALE
GILBERT RIVER
YARRAMAN
DUMBANC
TITTERSTONE
WOOLGAR RANGE
19° 30'
WOOLGAR
144° 30'
QUEENSLAND

INTRODUCTION.

The Etheridge Gold and Mineral Field, with an area of 12,178 square miles, lies at the base of Cape York Peninsula, nearly equidistant from Cairns and Townsville on the east coast and from Normanton on the west. Shipments have been made from all three ports at various times, but Cairns, owing to railway communication, at the present takes all traffic. The field is most irregular in shape, but is wholly included between latitude 17½ degrees and 19½ degrees south and between longitude 142½ degrees and 145 degrees east; and it is also within the catchment of the Gilbert River and its tributaries, the Einasleigh and Etheridge.

The Etheridge Mineral Field falls within the zone defined by the isohyets of 20 inches in the south and 30 inches in the north, and this is to say the rainfall is somewhere about 25 inches per annum. The rainfall graph for Georgetown during the past 21 years (as given in the Commonwealth Official Year Book) is a simple curve of parabolic form. It shows that the maximum precipitation is in January (a mean of 9 inches) and the minimum (zero) in July, during the long dry season.

The rivers of the Etheridge during the greater part of the year are sandy or rocky wastes, and even during their brief flood periods have never been utilised as transport agencies. In the early gold-mining days the wagon served as the only means of transport, but it has always been recognised that even the richest of the mineral deposits can be profitably exploited only with the aid of rapid transit. Motor-driven road cars have been tried in the most favourably situated parts, but they have served rather to accentuate the pressing need for the more reliable locomotive. Many and various have been the proposals put before the public for the opening up of the field by railway.

The earliest trial surveys were between Georgetown and Croydon, these passing through Durham and Cumberland and near a number of old mines.

Subsequently to the opening of the Chillagoe line from the east coast, the advantage of connecting therewith became apparent; and it was thought to run from Alma-den to Springfield (55 miles on the Etheridge Railway), then *viâ* Truxillo, Lancewood, and Angore to Dagworth, on the Einasleigh, and

thence across the Newcastle Range to Georgetown, whence the Charleston (or Forsayth) mines could have been reached by following up the Delaney. The total distance would have been, say, 180 miles as against 142 miles by the Einasleigh route. The line would have traversed much new and partly tried mineral country.

Another shorter way would have been to run out in an easterly direction from Georgetown, connecting with the present railway at a point about 6 miles south of Junction Creek; and this would also have opened up some only partly tested country east of the Newcastle Range; but in both this and the last case a branch line would have been necessary to link up the Einasleigh mine.

The Etheridge Railway as ultimately constructed, it will be remembered, runs from Alma-den, *viâ* Einasleigh, to Forsayth, a distance of 142 miles. It is the property of the Chillagoe Company, though constructed and operated by the State, which will take it over in 1921 at a price depending on the earnings of the previous five years.

After the erection of the big Havelock Mill near Forsayth the extension of the railway westwards to Mosquito Creek and then southwards to Ortona, with a branch to Percyville, was suggested. The country to be traversed between Mosquito Creek and Ortona is poor in mineral.

The claims of a much shorter route are now being advanced. This takes off from the Etheridge Railway at St. Paul's Gap on the Newcastle Range (118 miles from Alma-den) and, dropping down on to the Robertson, follows that river to its head, then crossing on to the Percy, and so down to Percyville. From that town the line could be extended southwards on to and along Granite Creek almost to Gilberton, when it would sweep round to the westwards, passing the Eight-mile mines and continuing across the sandstone range down to Ortona. Between St. Paul's Gap and Percyville it would be in country barren of mineral, but believed to be rich in timber. Between Percyville and Granite Creek and on the range between the Eight-mile and Ortona there is little or no likelihood of productive mining being carried on. It is conceivable, but by no means demonstrated, that the Ortona-Eight-mile belt could yield sufficient ore to warrant the construction of the railway.

Scope of Report.

The present report is the outcome of an application made during the year 1913 by the Chillagoe Company for a geological

examination of the country likely to be tapped by an extension of the Etheridge Railway. Since that line was opened to traffic, in 1909, the mines in the vicinity of the terminus have fallen out of the producing list, and the need of fresh sources of ore for the Chillagoe smelters has become pressing. The Chillagoe management, reviewing the position, has presumably come to the conclusion that developments in the Georgetown district, to the north of the terminus, would not warrant the extension of the railway in that direction; and its explorations in the Mosquito Creek silver-lead mines, to the west of the terminus, do not seem to have been of an encouraging nature. There remains then the country to the south, taking in Percyville, Gilberton, and Ortona. Percyville has been essentially a gold-mining centre, and it is not expected to be a great freight producer. Gilberton is still less likely to be of benefit; but there are a number of large untested lodes at the Eight-mile and Twelve-mile; and at Ortona copper ore is steadily being raised.

The company's real desire was an expression of opinion as to the probability of the many large outcropping lodes in this corner of the field being cupriferous in depth. My conclusions, as formulated at the end of the visit, were made available to the directorate in Melbourne early in the year.

Field Work.

Mr. J. Horsburgh in October last personally conducted me from Chillagoe over as much of the country as the prevailing droughty conditions would permit. He drove me from Forsayth to Percyville, where we were joined by Mr. W. Colley, the company's local manager and the registered holder of several of the properties to be inspected. From Percyville we went through Mount Hogan to Talaveras Springs and thence rode to Gilberton, and *viâ* the Eight and Twelve Mile Creeks to Ortona. The Percy was traced back to Percyville.

Subsequently I was driven out to Mosquito Creek by Mr. Hanrahan on behalf of Mr. J. Candlish, and to Glendowan by Mr. E. A. de Lautour, the manager of the Etheridge Gold Mines, Ltd.; and while at Georgetown the Warden, Mr. R. Curtis, assisted me to visit many of the surrounding mines. These flying visits served to give me a general impression of conditions existing on the field.

AREAL GEOLOGY.

The geological features of the Etheridge Goldfield have been so ably described by Messrs. Daintree, Jack, Maitland, Cameron, and Marks that little more is demanded of me than an epitome of their dicta.

In brief, then, we have on the Etheridge an irregular core of granite enclosed by schistose metamorphics, which shade outwards into but slightly altered though much disturbed sedimentary rocks, ascribed by Daintree [1] to the Silurian period. It is in these rocks, the granite, schists and slates, that the mineral veins are found. To the south-west the older rocks pass beneath gently dipping Cretaceous (?) beds, the former extension of which over the whole field is denoted by many outliers. The Newcastle Range is capped by such sandstone beds, but the main mass of the range is a barren porphyry of undetermined age.

Generally speaking, the geological conditions resemble those on the Cloncurry Mineral Field, where granites are surrounded by metamorphics (including amphibolite schist), and where also there are cappings of Cretaceous rocks, the two fields being, in fact, separated by a belt 200 miles wide of strata of that age. It is noteworthy also that the ore deposits of Cloncurry are predominantly siliceous and that jasperoid is a not infrequent constituent of the outcrops. On the other hand, metamorphism has not been nearly as intense here as at Cloncurry; and the rich secondary ores of the Cloncurry field are conspicuously wanting on the Etheridge. On the western field the deposits lie in shear zones, while here we have true fissures, joints, and bedded veins.

Older Sedimentaries.

The metamorphic rocks, gneiss, and mica- and talc-schists, of the Gilbert Ranges were by Daintree separated from the slates, quartzites, limestones, and shales of Gilberton, which latter, for convenience of classification, he relegated to the Silurian; but Messrs. Cameron [2] and Marks [3] make no distinction in age between

[1] General report upon the Northern District. By Richard Daintree, Esquire, late Government Geologist for Northern Queensland. Brisbane. By authority, 1870, p. 9.

[2] The Etheridge and Gilbert Goldfields. By Walter E. Cameron, B.A., Assistant Government Geologist. Brisbane. By authority, 1900. G.S.Q. Publication No. 151, p. 1.

[3] The Oaks and Eastern Portion of the Etheridge Goldfield. By E. O. Marks, B.A., B.A.I., Assistant Government Geologist. Brisbane. By authority. 1911. G.S.Q. Publication No. 234.

the schists and the slates; and to me also the schistosity appeals simply as an expression of extreme metamorphism of the sedimentary rocks. Where the action has been most intense the schists have interlaminated bands of quartz, aplite, alaskite, or pegmatite. The true "pegmatitic structure" is seldom seen, the term pegmatite being used in its general sense to indicate a rock consisting of coarsely crystalline quartz and felspar in variable proportions, with sometimes large masses of mica (particularly muscovite). Such a rock is most common in the Percyville district; and on the Einasleigh there is an even greater massing of the fine grained alaskite.

Many gold quartz reefs have been worked in the schists, as, for example, at Percyville, where eruptive after-action must have been most pronounced. The metamorphics seem to have been more favourable for the concentration of the base metals, more particularly lead and copper, as typified on Mosquito Creek and at the Einasleigh. The less altered slate country has also its copper lodes at the Eight-mile, Gilbert, and its lead lodes on Mosquito.

In both slate and schist the intimate relationship between mineralisation and igneous action is witnessed by the numerous porphyry and diorite dykes in the vicinity of the lodes.

Diorite.

Diorite, otherwise described by Daintree with diabase, aphanite, etc., as greenstone, occurs in the form of wide dykes on the Gilbert, on the Percy, on the Einasleigh, and on Mosquito Creek. These dykes mostly show evidence of crushing, and were presumably intruded prior to the earth movements resulting in the well marked schistosity of the metamorphics, and thus they are older than the granites, in which, of course, they are not found. In parts the diorite has been altered to amphibolite-schist, which under superficial observation might be passed by as mica-schist. Diorite dykes are not restricted to lightly metamorphosed areas such as Einasleigh; but characterise as well those of slight induration, such as Ortona.

In some places the dyke alone is the country rock of the copper ore-bodies, but even where the larger deposits are encased in schist there is always contiguous diorite.

Granites.

Daintree from the first regarded the granites as of metamorphic origin (transmuted mica-schist he termed it), and the temptation to follow him is strong. The general facies of the rocks is decidedly not plutonic. It is often schistose and banded.

but seldom crystalline granular, though a porphyritic structure is well developed. A few years ago it would have been regarded as a clear case of a rise in the isogeotherms over the area, causing liquefaction of the deeper parts of the sediments thereon, for local intrusions there were undoubtedly, and there are also pegmatite veins and segregations such as could only be derived from a cooling magma. It is remarkable that where the evidence of intrusion is strongest there the surrounding sedimentaries have been least altered, and are most free from eruptive after effects, such as greisenisation. Allowing, however, in deference to general opinion, that the granite is intrusive, it is plain that the present land surface is not far below the summit of the intruded batholith. Consequently, the schistosity of the surrounding metamorphics is not due to expansion of melting sediments nor to the intrusion of the granite magma, but to orogenic forces whereby the sedimentaries were thrust against the unyielding solidified igneous mass. The actions involved are of extreme and more than academic interest, but they require for their elucidation a long term in the field and much petrographic study.

The granite is the home of the majority of the auriferous quartz-veins of the Etheridge, these being most numerous near Georgetown in the north, and Charleston (or Forsayth) in the centre, with some near Percyville in the south. They have a tendency to conform with the general east-west structural lines of the field.

Porphyries.

No critical examination has ever been made of the Newcastle Range porphyries, yet of late there has been manifest an inclination to regard them as intrusives. Their connection with great dykes has certainly been demonstrated by Mr. E. O. Marks,[3] but Mr. A. Gibb Maitland[4] had long previously published petrographical descriptions of rocks from the range, on which one would assume the presence of some extrusive.[5] Dr. R. L. Jack[6] has gone further and actually described "bedded trachyte lava and coarse volcanic ash on the divide [a spur from the Newcastle Range—L.C.B.] between Goldsmith's Creek and the Robertson River." The same observer noted that the Desert

[4] Annual Progress Report, for the Year 1891, of A. Gibb Maitland, Assistant Government Geologist. Brisbane. By authority. G.S.Q. Publication No. 87, p. 25.

[5] These are references to laminated and fragmental spherulitic rocks and to fragments of "A brecciated felsite embedded in a lava-like matrix, ... with everything pointing to the conclusion of the rock having originally been a rhyolitic lava."

[6] The Geology and Palæontology of Queensland and New Guinea. By Robert L. Jack, F.G.S., Etc., Government Geologist for Queensland, and Robert Etheridge, junr. Brisbane. By authority, 1892, pp. 523 and 629.

Sandstone of the range "rests on a thickness of about five hundred feet of a clastic rock, resembling a felspar porphyry," and later he spoke of the range being "built up from an elevation of 1,920 ft. at its base to 2,240 ft. near its summit of a coarse angular volcanic agglomerate." Mr. Cameron [7] is equally positive that the rock composing the southern part of the range is "an acid intrusive rock—a quartz-felspar-porphyry or eurite"; but, from his mapping of the north-western edge of the porphyries, only one deduction is possible—that in the northern part these rocks cap the granite and are there extrusives. In this place I might draw attention to the lithological similarity between the igneous rocks of the Newcastle Range and those of the Feather-bed Range on the Chillagoe Mineral Field. The

PHOTO. 1.—SANDSTONE KOPJES.

A QUARTER OF A MILE SOUTH OF TALAVERAS SPRINGS, GILBERT.

Note both the thick and thin beds, the false bedding of the former being masked by surface pitting (Karst phænomena). The timber is mountain gum.

latter have been shown [8] to be of Permo-Carboniferous age, and to be in part at least volcanic. They are probably coeval with the fluidal porphyric breccias of the Silver Valley described by Mr. James Stirling.[9]

[7] *Op. cit.*[2], p. 2.

[8] Mount Mulligan Coalfield. By L. C. Ball. G.S.Q. Publication No. 237, p. 9.

[9] Monograph on the Geology and Mining Features of Silver Valley, Herberton, N.Q. Published by the Lancelot Freehold Tin and Copper Mines, Limited, 1905.

The porphyries have nowhere been proved payably metalliferous, but the dykes of porphyry, felsite, and rhyolite have had some genetic connection, as yet not thoroughly understood, with the copper deposits, *e.g.*, at the Einasleigh and at the Union Mine, Percyville. They are not confined to the metamorphics, the early reports to the contrary notwithstanding.

Newer Sedimentaries.

The coarse grits and conglomerates of the hills and ranges form horizontal beds, exhibiting well-marked current bedding. Shales seem to be non-existent and search for well-preserved fossil plants is almost hopeless, the absence of petrified wood being a warning sign. The total thickness on the Etheridge is believed to be nowhere more than 100 ft., and on most of the hills 50 ft. is the maximum. These caps have been classed by the

PHOTO. 2.—FALSE-BEDDED SANDSTONES.

ABOVE TALAVERAS SPRINGS, GILBERTON.

Geological Survey as Desert Sandstone (Upper Cretaceous). Other strata of like nature met on the lower country Mr. Cameron [9] says "may possibly be older coastal formations forming part of the basal beds of the Lower Cretaceous."

No mineral deposit of any kind has yet been discovered in the Cretaceous beds. On the contrary, they cover large areas of the schists and granites, and hide, we may be sure, many metalliferous deposits. However, the beds are highly absorbent and

[9] *Op. cit.*[2], p. 3.

serve as storage reservoirs in a generally drought-stricken country, and they give rise to numerous springs of water, without which much of the country would be uninhabitable during several

PHOTO. 3.—LANCEWOOD AND MOUNTAIN GUM.

ON THE SANDSTONE PLATEAU AT THE HEAD OF THE LITTLE ROBERTSON.

months in the year. Also, in spite of the sandy nature of their soil, they support a comparatively luxuriant growth of lancewood (an acacia much sought after for mine timbers).

Basalt.

The only remaining group of rocks requiring notice are the basalts. These form extensive flows along the eastern side of the Etheridge Field and they are said to occur on Agate Creek. A single dyke was noticed by me at the junction of the Percy River with its tributary Blacoe Branch.

The extrusion of the basalt does not seem to have been associated with any unusual activity in ore concentration in this district.

ORE DEPOSITS.

The granite country is characterised by gold-bearing quartz reefs, seldom of large size and always carrying a small percentage of sulphides, among which are those of iron, lead, zinc, and copper. Mr. Cameron has noticed [10] that the reefs lying wholly within the granite are the most heavily mineralised, consisting as they do in places below the water-line of solid masses of pyrite and galena or both, with smaller admixtures of chalcopyrite and blende. He, however, shows [11] that in the four deepest mines there has been a sudden impoverishment below the 300-ft. level, and he accounts for it on the theory of deposition from ascending hot alkaline solutions. The generalisation is rather a sweeping one for such an extensive field, and there is hope that the rule may not apply throughout. The possibility of encountering deeper shoots should not be overlooked.

That the auriferous section of the metamorphics on the Gilbert are penetrated by elvanite dykes was noted by Daintree [12] more than 45 years ago; and the effect of diorite as a mineralising agent in the slate areas was observed by him at the same time.[13]

The lodes in the metamorphics, of which the Einasleigh is the greatest, show a tendency to a lenticular habit, the shoots being short and not restricted to a single fissure.

The outcrops of the lodes in the slates seldom consist wholly of quartz, but they mostly are marked by the presence of jasperoids accompanied by more or less gossan. Some bunches of rich ore have been discovered along the course of a few of them, but the total amount actually in sight is quite insignificant. The lodes are of promise because of their linear extension, as proved by the crops; because of their width, which in places is considerable; and because of the secondary minerals forming the crop, these pointing to active mineralisation with the probability of metallic values in depth.

[10] *Op. cit.*[2], p. 3.

[11] Second Report on the Etheridge Goldfield. By Walter E. Cameron, B.A., Assistant Government Geologist. Brisbane. By authority, 1909. G.S.Q. Publication No. 219, p. 6.

[12] *Op. cit.*[6].

[13] *Op. cit.*[1], p. 7.

The galena and copper lodes of the Gilbert had already attracted attention in the early eighties,[14] and some work was actually done in 1881 on lead lodes near Gilberton. At the same time, alluvial bismuth ore was being saved on the Percy. Nevertheless, no real effort has yet been made to test any of the larger outcrops, which, notwithstanding their poverty in metallic ores, are well worth prospecting. On more accessible fields such crops would be looked on with favour and long ago shafts would have been sunk to the sulphide zone.

At Mosquito Creek, again, but little has been done to test the lodes below water-level, where low grade mixed sulphide ore may be confidently expected. The concentration of ore in the Mosquito area can be directly attributed to the partial engulphing of that area in the granite magma, the intrusives lapping round the metamorphics on the east and north.

Ores.[15]

The quartz reefs in the granite country as they stand probably contain no more than 5 per cent. sulphides on the average, but exceptionally they may be richer, and there have been published [16] analyses of exhibition samples from some of the chief mines to show their adaptability to smelting. These ran as below:—

Cu = 18 to 32 %; Pb = trace to 1½ %; Fe = 15 to 32 %; and SiO_2 = 25 to 59 %.

It has been shown also that the precious metals are associated more particularly with the minerals galena and pyrite, the highly zinciferous ores being generally discarded as too low to pay for treatment. Arsenical pyrite has been reported on more than one occasion, but its presence has not been confirmed, nor has that of antimony, but bismuth has been chemically detected in concentrates from the Havelock Mill.

In the lead deposits we find cerussite and anglesite with ochre in the oxidised zone, and increasing quantities of galena towards water-level. The presence of siderite becomes manifest in the deeper parts of both lead and copper deposits. The mineral is often associated with blende, for which, after exposure to the air, it is liable to be mistaken.

[14] Warden's Reports. Annual Reports of the Department of Mines for 1881 (W. M. Mowbray), and 1883 (W. Samwell). Brisbane. By authority.

[15] In the assay results quoted below the following chemical symbols or contractions have been used throughout:—Cu = copper, Ag = silver, Au = gold, Pb = lead, Zn = zinc, ZnO = zinc oxide, Fe = iron, FeO = ferrous oxide, Bi = bismuth, S = sulphur, Insol = insoluble, CaO = lime.

[16] *Op. cit*[2], p. 7.

A very little chalcocite is found with malachite and azurite in the caps of copper lodes, but all three minerals give way to chalcopyrite in depth. Native copper is extremely rare.

The caps of the copper lodes are highly siliceous, but the silica is present in only subordinate amounts as white quartz, most of it being combined with iron oxide as red and yellow jasperoid.

Distribution.

A very fair idea of the distribution of metallic ores on a proclaimed field may be derived from the plotting of all mineral holdings, as on the attached map (frontispiece), which has been compiled from the official registers at Georgetown.

Omitting *gold* and *silver*, to illustrate the distribution of which a separate map would be needed, it will be observed that *lead* is the most widely spread of the industrial metals. Mosquito and Durham may be regarded as the chief productive foci of an extensive area near the centre of the field, and deposits at Gilberton, Percyville, Einasleigh, and Macdonaldtown have also been worked.

A great *copper*-bearing belt lies in the south-eastern part of the field and this includes the Einasleigh Freehold mine besides the deposits on the Gilbert and Percy, described below. Other occurrences there are too in the lead country to the north-west, about Charleston, Georgetown, and Cumberland, where, however, the copper is more often than not an accessory to lead and zinc. Still another discovery has been made at the head of the Little River in the western end of the field (beyond the confines of this map).

Zinc is a frequent constituent of the auriferous sulphides throughout the field, and as blende it is sometimes present to the exclusion of the other metals, as at Donnyville.

Pneumatolytic effects are widespread, but there has been no marked concentration of the characteristic metals, except at Angore, which geographically belongs to the Chillagoe Field. *Tin* has been worked at Buchanan Creek and on the Robertson; *tungsten* on Buchanan Creek and the Copperfield; *bismuth* on the Gilbert and Percy (in the latter case being associated with *tantalum* ore); and *molybdenum* is an occasional if rare constituent of the Einasleigh ore.

EIGHT-MILE, GILBERT.

This copper-bearing section is separated geographically from that of Ortona by a low sandstone-capped range, but of the essential unity of the two areas we may be sure, they being plainly part of one petrographical and mineralogical district.

The indurated slates and impure limestones forming the basement are usually tilted at high angles northwards, and they are believed to belong to one of the early Palæozoic systems. They have been intruded by great stocks or dykes of diorite and subsequently by quartz-felspar porphyry. Beyond a general association, no direct relationship has been traced between the ore-bodies and the porphyry; but the effect of the diorite on the occurrence of copper ore is most marked.

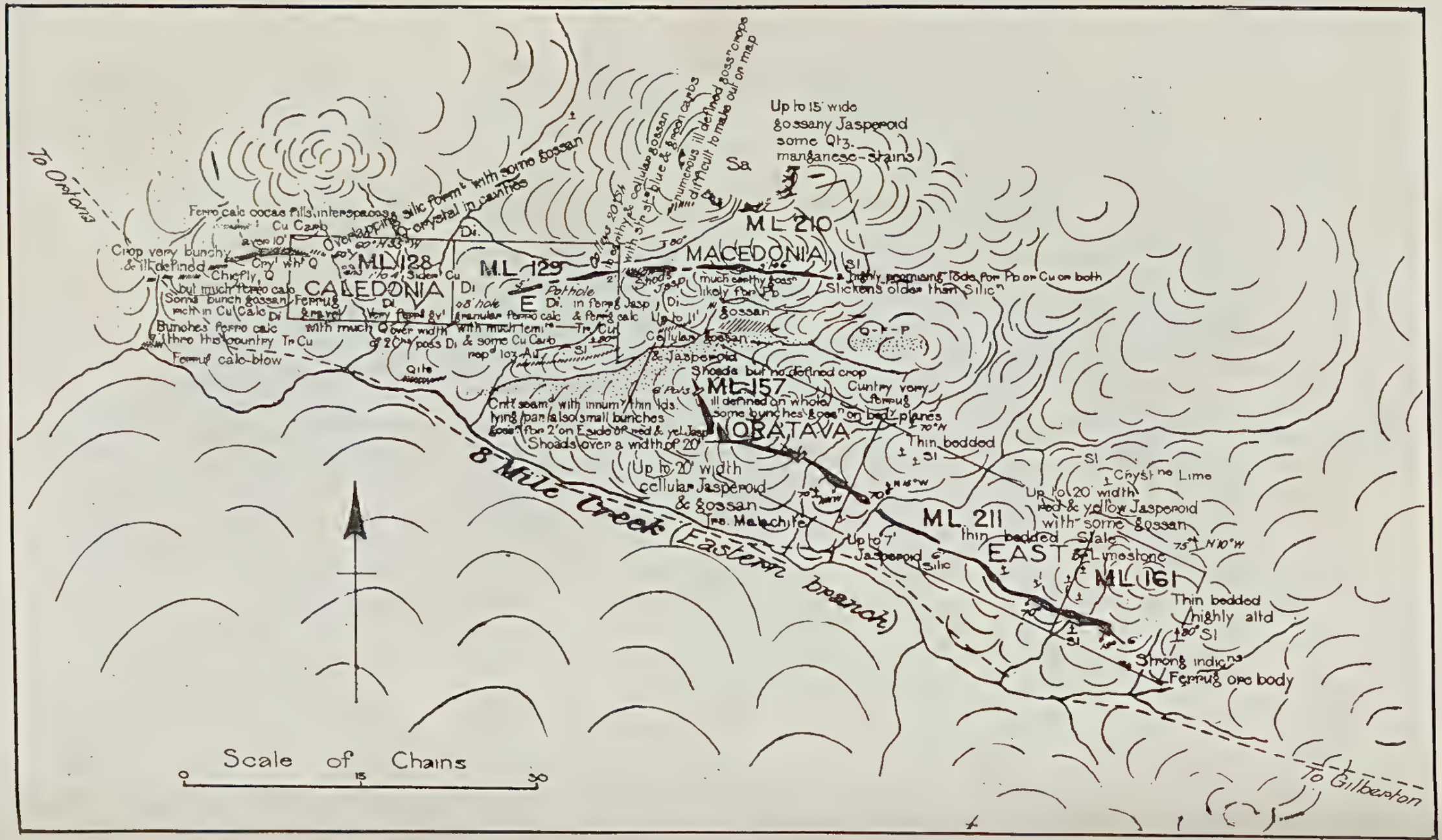
It is reported that there is a number of lodes[17] in this vicinity, but during my visit inspections could be made of only three main lines—the Oratava, Caledonia, and Ironclad—besides Donoghue's workings to the south and west of the Caledonia, these last being of no economic promise. Many of the crops are yellow stained and look promising for lead in depth, but several samples taken by Mr. Horsburgh from different crops afforded on assay not even a trace of the metal.

The Oratava crop in particular is impressive in its size and in the evidence of recent chemical activity in its gangue. The judicious expenditure of capital in systematically prospecting the lode below water-level would in all likelihood prove large stores of low-grade ore here.

Caledonia.

What is known as the Caledonia lode probably comprises two distinct lines. The western has been worked on the old Caledonia lease and on the adjoining Caledonia No. 1 West. This consists of a number of overlapping bunches of siliceous material with some gossan and much crystallised quartz, ferro-calcite filling interspaces. It has an average width of 10 ft., and can be traced for over ten chains. Where the crop is most prominent it exhibits little sign of copper, but some rich ore has been won on the low ground to the east. Two shafts have there

[17] One of these has since my visit been applied for as the *Macedonia*, Mr. Colley's sample from the crop yielded:—Cu = 6·32 %; Ag = 0·33 oz. per ton; Au = 0·03 oz. per ton; and Pb = nil.



SKETCH PLAN 1—COPPER LODES, EIGHT-MILE, GILBERT.

been sunk, one 40 ft. and one 50 ft., and from them and the intervening stope Clark and party raised 50 tons of ore carrying:—

Cu=29 to 30 %, with Ag=10 to 12 oz., and Au=7 dwt. per ton.

The 10 per cent. seconds at grass amount to 10 tons, and it is estimated that in the dumps there is 100 tons of 5 per cent. ore. The metalliferous part of the lode is 1 to 4 ft. wide and very ferruginous, consisting as it does chiefly of ferro-calcite or of chalybite and limonite.

The crop on the Caledonia East and the lately acquired Macedonia is traceable with only short breaks for more than a quarter of a mile. Its width is variable, mostly more than 5 ft. and in places quite 15 ft.; and it stands sometimes 12 ft. above the ground. Red or yellow jasperoid forms the greater part of

PHOTO. 4.—CALEDONIA NO. 1 EAST, FROM THE NORTH.

NOTE THE POVERTY OF THE TIMBER (IRONBARK AND DESERT GUM)

the crop, but much of it is cellular or cavernous and gossany, besides being strongly manganese-stained. Quartz is much in evidence in some parts. Generally speaking, it has the appearance of an iron cap, and copper or lead might be expected in depth. As a matter of fact, copper ore has been unearthed in the western part of the crop; and from Colley's old 20-ft. shaft there has been raised 5 tons of 10 per cent. ore, while 50 tons of

formation in the tip should average 5 per cent. copper.[18] The shaft is now inaccessible, but, from the surface indications along the whole line, I have no hesitation is recommending that sinking to a depth of, say, 200 ft. be undertaken with a view to proving the possibilities of the lode, for, notwithstanding that the lode strikes with the slates, I regard it as likely to be permanent, and due to the intrusion of the diorite that crops to the south of the lode.

Ironclad.

The Ironclad or Magazine crops are mostly small and scattered. Those seen in the east are mostly along the contact of a large diorite dyke, but there is a possibility of large formations being found in the enclosing slates. At the western end, just below the sandstone cap, there are several outcrops adjacent to a diorite dyke. One of these is 1½ chain long and comprises 12 ft. width of red and yellow jasperoid and white quartz alongside of 10 ft. width of ferro-calcite, gossan, and jasperoid. These minerals give way to the east to massive and granular hæmatite, associated with some jasper.

A shaft, now caved, was sunk 15 ft. in the westernmost crop, and 10 tons of 25 per cent. copper ore was picked from the formation broken down. There is still 2 tons of firsts [19] at grass, and the 25-ton dump should yield between 5 and 10 per cent. copper This result is much better than would have been predicted from the general nature of the crops, and it should be an inducement for some further developmental work.

The general trend of the ore-bodies is west-by-north, whereas the strike of the slate is east-west, proving that they are not bedded deposits.

Oratava.

The Oratava line outcrops for a distance of half a mile with an average width of 10 ft., the limits being zero (in one or two places) and 25 ft. The crop consists chiefly of yellow jasperoid or chert, in many places cavernous and in those cases gossany as well, and there are occasional traces of copper carbonates.

The few shallow workings on the crop are of little use as exposures, shafts to 100 or 200 ft. depth being urgently needed. As a prospecting venture the sinking of such is in every way

[18] Assays of samples made for Mr. Linedale of Ortona show that the ore from the Caledonia line is consistently low in silver, the proportion being only 1 oz. for every ten units of copper. Some of the ore carries a trace of zinc.

[19] Mr. Linedale had a sample of this assayed, the result being as follows:—Cu = 27·5 %, and Fe = 22 %.

desirable, as we may expect a considerable reduction in the silica content with distance from the surface and a gradual improvement in the metal contents at the same time.

That the lode occupies a fissure may be taken as certain, because it strikes at an angle of 30 degrees with the slates and dips in the opposite direction to them. The country is thin-

Photo. 5.—Oratava Main Crop, from the North-east.

bedded slate and impure limestone in no way contorted, but dipping at a high angle to the north-by-west. A belt of quartz-felspar-porphyry or rhyolite obliquely crosses the line of strike a few chains beyond the western end of the crop, and beyond the porphyry again is diorite, which in this district is everywhere associated with the copper deposits.

TWELVE-MILE, GILBERT.

The geological associations here are similar to those at the Eight-mile, the ore-bodies occurring in thin-bedded slates along an east-west line near an intrusion of diorite.

The only leases applied for are Carson's and its numbers including that known as the Castle, which is half a mile east of Carson's workings. The further opening up of the lode discovered in the shaft on Carson's is an undertaking to be specially recommended.

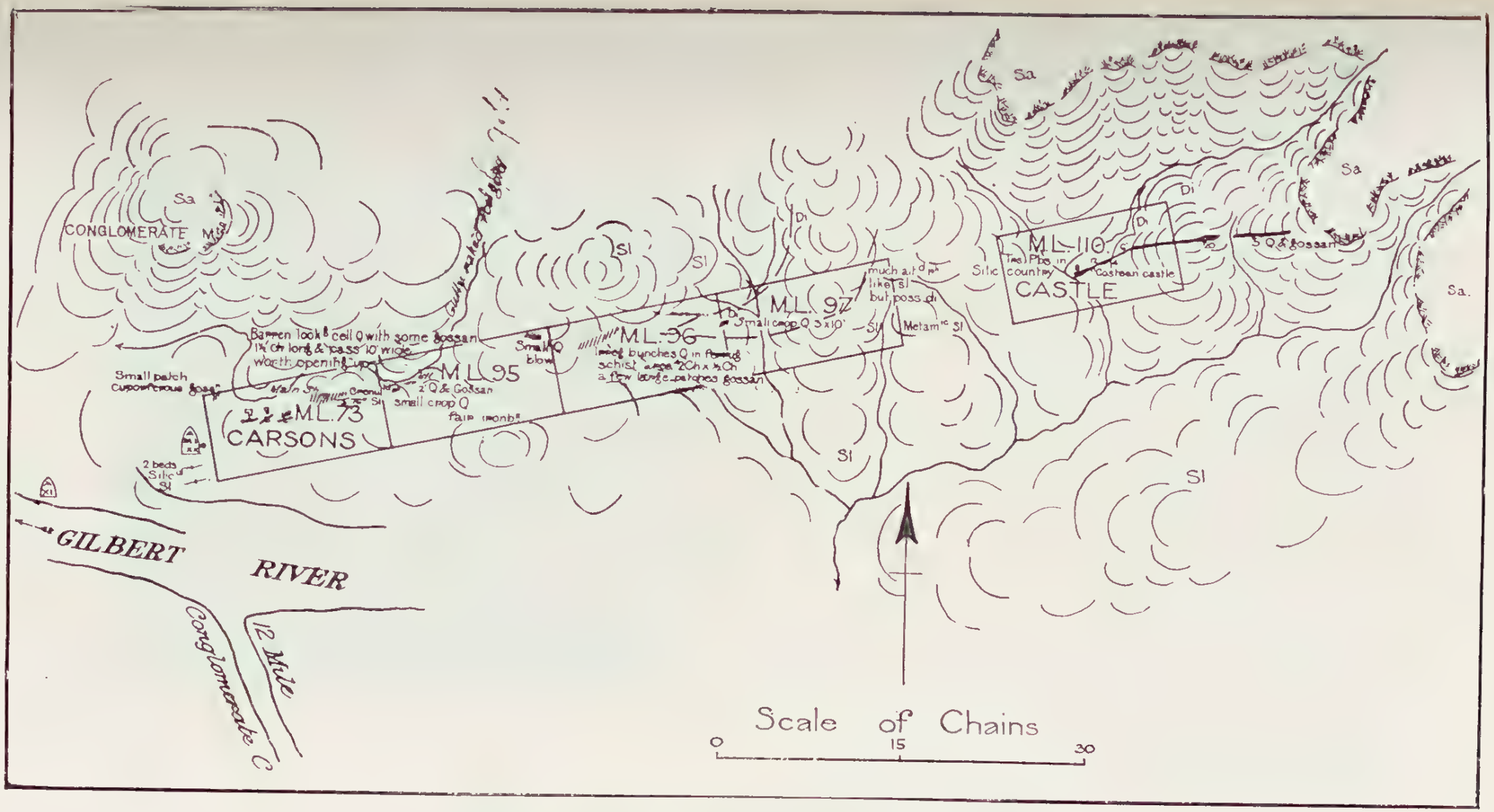
Carson's.

On Carson's and its numbers to the east there are several inconspicuous outcrops of quartz and quartz-veined, highly ferruginous, crushed country (thin-bedded clay-slate).

A shaft has been sunk 50 ft. on one of these ferruginous areas, having a length of 2½ chains and a maximum width of

PHOTO. 6.—CARSON'S, TWELVE-MILE, GILBERT.

1½ chain. Some rich ore was got near the top of the shaft and the first parcel of 12 tons was carted 15 or 16 years ago to Townsville to be railed to the coast. A total of about 25 tons of



SKETCH PLAN 2—COPPER LODES, TWELVE-MILE, GILBERT.

ore is said to have been shipped. The shaft passed through about 7 ft. of country rock veined with gossan; and that if followed down on the underlie should be found to pass into a sulphide-veined formation, probably of low grade.

From the shaft bottom a crosscut was put 15 ft. into the footwall of this formation, and it passed through gossan- and quartz-veined formation for 10 ft., and then into a gossan lode, which, including slabs or horses of country rock, is 5 ft. wide. This is a very fine cellular gossan with some copper carbonates and glance. About 10 tons of 5 per cent. ore (dense limonite with disseminated malachite, cuprite, and glance) was set aside from the material raised; and besides this there is a few hundredweight of richer ore that should average over 20 per cent., some of it containing at least 50 per cent. copper.

Castle.

The Castle crop can be followed for nearly a quarter of a mile from a gully opening into the Gilbert River to the sand-

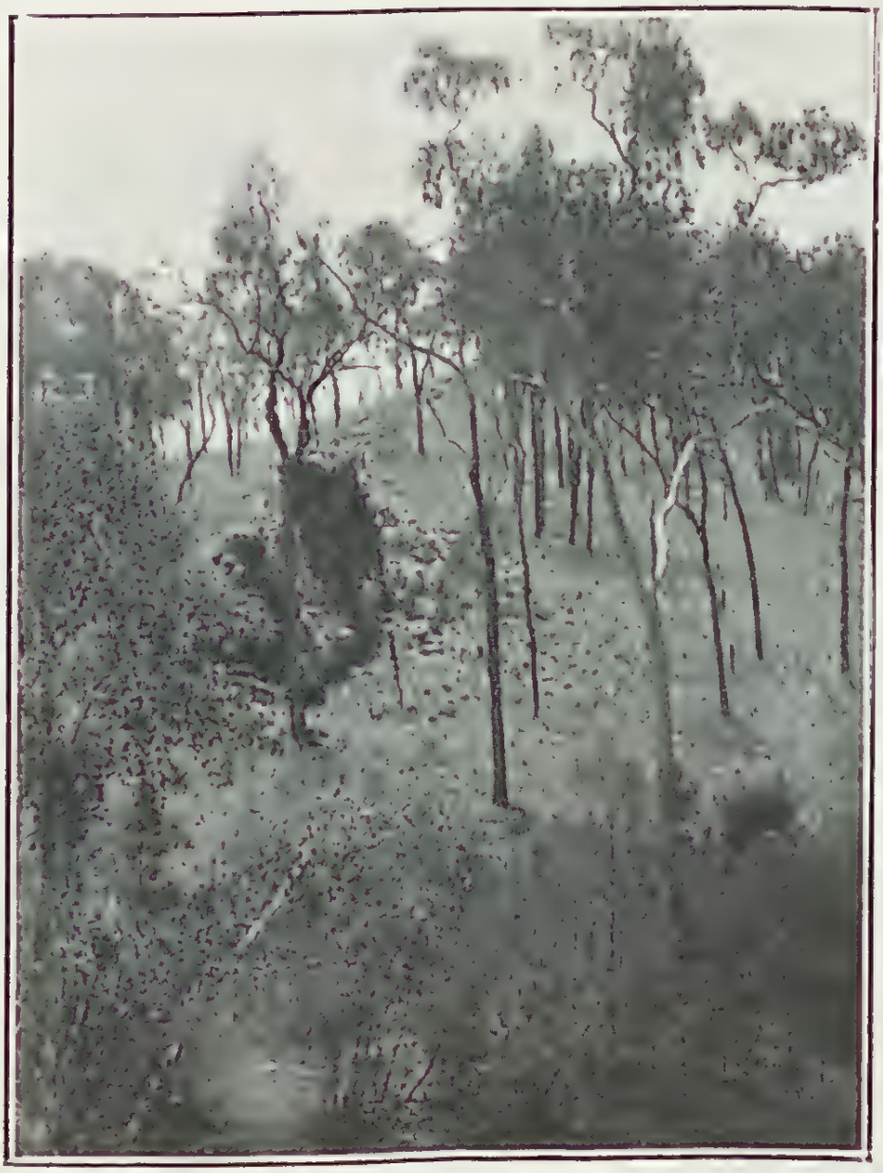


PHOTO. 7.—MAIN CROP ON THE CASTLE, TWELVE-MILE, GILBERT.

stones capping the hills above. It consists largely of quartz, chert and jasperoid being present in only minor quantities, but cellular gossan is plentiful and in some places is equal in amount to the quartz. It is most prominent at the western end, and there it stands 20 ft. out of the ground. There is no payable ore in sight, but the gossan is of a very kindly nature and development is warranted. Some needed prospecting could be effected by means of an adit to be driven along the line from the lower part of the crop.

ORTONA.

In the canon of the Percy River, a few miles above the Gilbert, a number of leases, including the Ortona, Orsova, Orvieto, and Orontes, have been pegged out.

The Percy River has here entrenched itself in the sandstone plateau, revealing the underlying slates and limestones with intrusions of diorite and copper lodes in association therewith. The canon has a width of little more than 2 miles, and the country along it is regarded as promising for only 8 miles. It may reasonably be inferred to be an extension of the copper belt of the Eight- and Twelve-mile, Gilbert, from which it is geographically isolated by a sandstone range.

Lithologically the Percy and Gilbert areas are identical, but, while on the latter the copper occurs in both igneous and sedimentary rocks, on the former it is restricted to the diorite dykes, which are crossed from wall to wall by fissures or unusually well-defined contraction joints. There is reason to believe that the great north-south dyke of the Ortona lodes is continuous with that running east and west and in which are the Orontes, Orsova, and a number of unnamed lodes.

The Ortona was discovered thirteen years ago, and in a small way has been worked intermittently ever since, with from five to twenty men. Outside of the large lease secured many lodes have been discovered, but, as none was rich on the surface, little or no work has been done on the majority of them. Shows were taken up on Brown's Gully and on the Percy, a little way above the old hotel, but the amount of labour expended on them was negligible. On one of the numerous crops in the diorite dyke that runs out to the east of the hotel, a shaft was sunk 50 ft. for some return, but the net result was unprofitable because of the inaccessibility of the locality. Three new leases have quite lately been pegged out.

The prospects of the Ortona lease lodes are much discounted by the fact that the copper does not live out of the diorite country. As the map shows, the greatest length of crop is less than 10 chains, and some of the crops are less than 1 chain long. The total length of the crops reaches the respectable total of 50 chains, but only a fraction of this can be expected to yield ore. The lodes are of but moderate size and consequently are not to

be relied on for a large production, even for a time with operations on an inflated scale. Unless the lodes prove to be highly pyritic at greater depths, it is extremely doubtful if the normal production would warrant the construction of a railway extension from the Eight-mile.

Orontes.

This lease, pegged out since my visit, takes in at least two lodes. One of these is 3 chains long and probably several feet in width, but ill-defined. The gangue material is gossany jasper. The second crop, which is 3 chains further east, also has a length of 3 chains. An old 50-ft. underlie shaft on this has now caved, but from it something over 30 tons of ore was shipped *viâ* Hughenden and Townsville. This carried 27 per cent. copper, and the 30 tons seconds at grass is expected to yield 18 per cent. It is siliceous limonite stained with malachite and azurite and carrying some glance.

Orsova.

The Orsova includes a most prominent crop of ferruginous and cupriferous jasperoid quite 10 ft. wide in the central part,

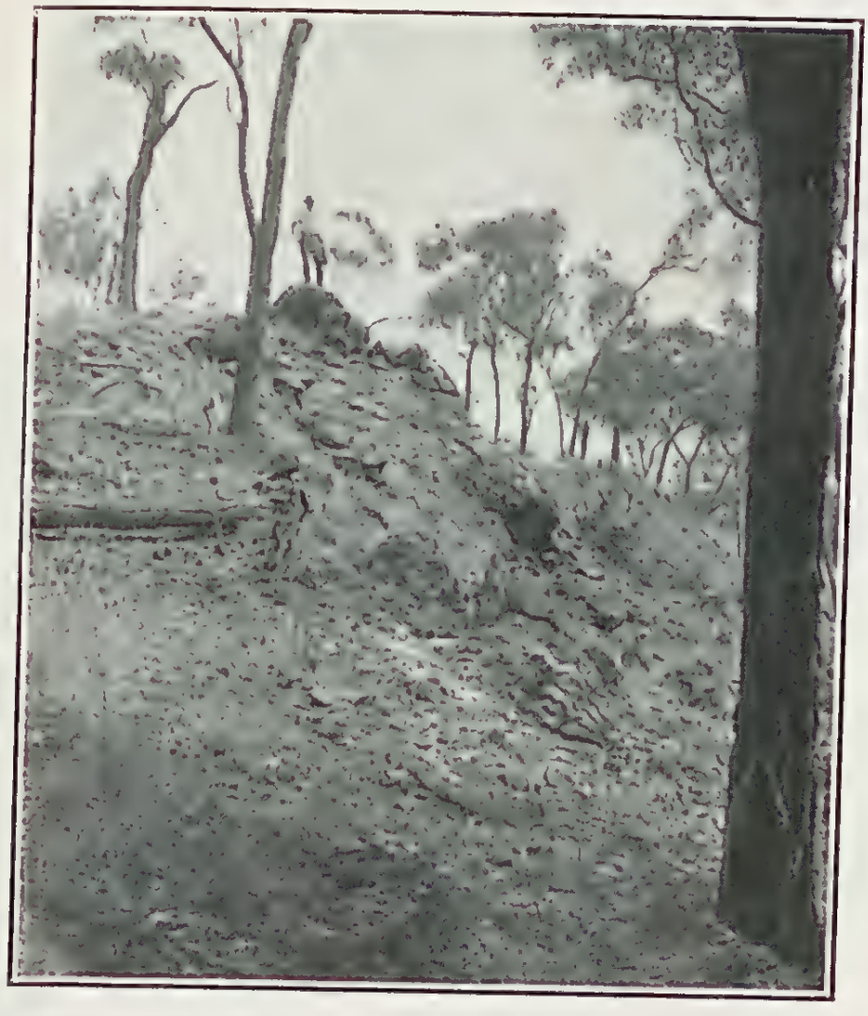


PHOTO. 8.—CLARKE AND COLLEY'S NO. 6 CROP, ORSOVA.

but tapering off towards the slate contacts. The total length of the crop is 5½ chains. A little chipping across the cap, where only iron and manganese stains were visible on the surface, showed unexpected values, the copper content amounting to at least 5 per cent. The crop is well worthy of prospecting, and the lode may become a moderate producer, but limits are set to its possibilities by the fact that it does not extend into the slate on either side of the diorite dyke.

Orvieto (?).

On a diorite bluff, below the most southerly bend of the Percy River, there are numerous short gash-veins of siderite, quartz, and hæmatite. It is believed that these are included in the Orvieto lease, pegged out since my visit.

Ortona.

On the Ortona lease there are thirteen distinct and nearly parallel lodes, all of which trend across a large but irregular dyke of diorite, beyond the limits of which mineralisation has seldom been operative. They do not seem in any case to have been very rich at the surface, but gratifying features have come to light as a result of the large amount of exploratory work carried out here.

Mr. A. Linedale, the owner, was absent during my visit, but on his behalf the manager, Mr. M. Reid, extended every courtesy towards me, even permitting me to examine the assay registers at the mine. Of these copious extracts were made by me, but the incompleteness and want of system of the sampling and recording in the early days do not allow of any attempt to estimate reserves on the figures available. The value of the underground explorations is thus much depreciated.

There is an entry of 89 tons of 33 per cent. ore shipped in 1904 and another of 165 tons of ore sent to England in 1907; but a complete record of production is not to be had. The manager in 1908 estimated that there was a total of 2,145 tons of ore at grass with from 3 to 33½ per cent. copper and from 1½ to 65 oz. silver per ton—the averages being—

Cu = 13½ % and Ag = 12½ oz. per ton.

The wardens also have reported from time to time that quantities of ore were stacked at grass, the total at the end of 1911 being 2,500 tons, containing:—

Cu = 15 % and Ag = 1½ oz. per ton.

From Mr. Reid I learn that between May, 1913, and the end of

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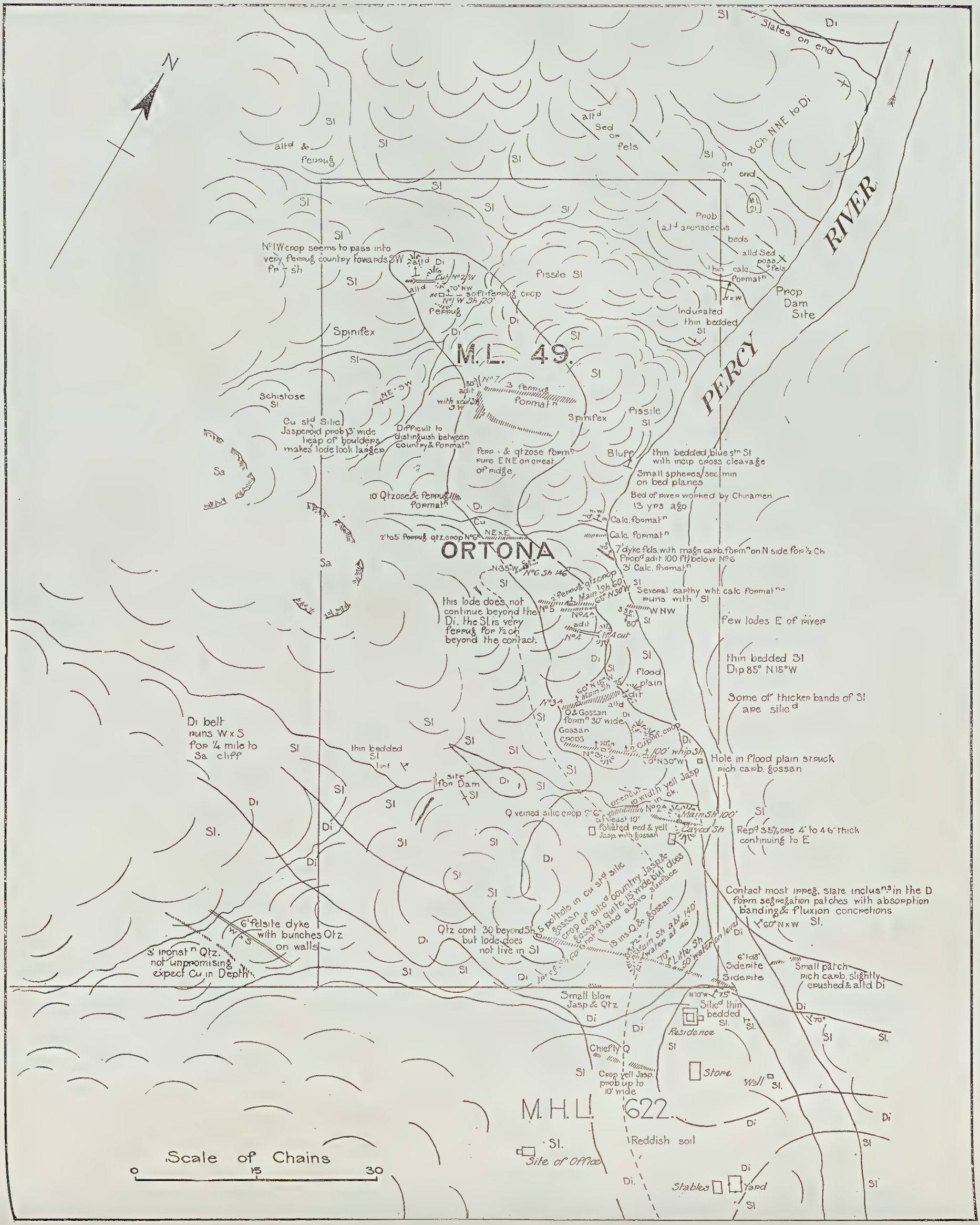
N
Sl
Di
Slates on end
alt^d & ferrug
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8 Ch NNE to Di
on end
Prob alt^d arenaceous beds
alld Sed poss fels
thin calc formatn
Indurated thin bedded Sl
Prop Dam Site
RIVER PERCY
Fissile Sl
N°1 W crop seems to pass into very ferrug country towards SW fr ½ sh
alt^d Di
Cut N°2 SW
70° NW
30 Ft. ferrug crop
N°1 W Sh 20'
ferrug
Spinifex
M.L. 49.
Schistose Sl
NE - SW
80' adit with xcut SW
N°7
3 ferrug formatn
Cu std Silic. Jasperoid prob 3' wide heap of boulders makes lode look larger
Difficult to distinguish between country & formatn
ferrug & qtzose formn runs ENE on crest of ridge
Bluff
thin bedded blue stn Sl with incip cross cleavage
Small spheres sec min on bed planes
Bed of river worked by Chinamen 13 yrs ago
10' Qtzose & ferrug formatn
Calc. formatn
2' to 5' ferrug qtz. crop N°6
N.E. x E.
ORTONA
7' dyke fels with magn carb. formn on N side for ½ Ch
Propd adit 100 ft below N°6
3' Calc. formatn
N-35°-W
S.
N°6 Sh 146
Several earthy wht calc formatns runs with Sl
this lode does not continue beyond the Di. the Sl is very ferrug for ½ ch beyond the contact.
ferrug qtz crop
Main Sh 60' 65° N30°W
N°5
N°4 adit
N°4 cut
few lodes E of river
thin bedded Sl Dip 85° N15°W
flood plain
N°3 adit
Main Sh 75' 60° N15°W
Some of thicker bands of Sl are silic^d
Q & Gossan formn 30' wide
Gossan crops
Gossan crop
100' whip Sh
70° N30°W
Hole in flood plain struck rich carb. gossan
Di belt runs W x S for ¼ mile to Sa. cliff
thin bedded Sl
Site for Dam
opencut 10' width in yell Jasp ck.
N°2 A
Main Sh 100'
Q veined silic crop 2' 6" at least 10'
foliated red & yell Jasp with gossan
Caved Sh
Repd 35% ore 4' to 4 6" thick continuing to E
Contact most irreg. slate inclusns in the D form segregation patches with absorption banding & fluxion concretions
Y 60° N x W Sl.
5 potholes in cu std silic gossan
crop of silic country Jasp & gossan quite 15' wide but does not stand above surface
Qtz cont 30 beyond Sh but lode does not live in Sl
18 ins Q & gossan
Main Sh abt 140' water at 46'
Lode Sh
50' waterlevel
6' felsite dyke with bunches Qtz on walls
3' ironst^n Qtz. not unpromising expect Cu in Depth
6" to 8" Siderite
Siderite
Small patch rich carb. slightly crushed & altd Di
Small blow Jasp & Qtz
Silic^d thin bedded Sl.
Residence
Chiefly Q
Crop yell Jasp prob up to 10' wide
Store
Well
M.H.L. 622.
Sl.
Site of Office
Reddish soil
Stables
Yard
Scale of Chains
0 15 30

ROUGH SKETCH PLAN 3—MINERAL LEASE NO. 49, ORTONA.

Face p. 31.

January, 1914, there has been despatched 76$\frac{5}{20}$ tons ore, containing:—

Cu = 24½ %; Ag = 17 oz. per ton; and Au = 1½ dwt. per ton.

The lodes are known as follows, beginning at the south:—Nos. 1, 2, 2A, 3, 3A, 4, 4A, 5, 6, 6A, 7, 7A, 1 west and 2 west; and they are spaced at intervals of: 7, ¼, 3, 2½, 3½, 1, ¼, 2, 2, 6, 2, 5, and ¾ chains. These are indicated on the accompanying sketch, whereon are also shown the confines of the diorite. The positions of the shafts were taken from the mine plans, which were found, when too late for correction, to have no pretensions to accuracy.

No. 1 Lode is traceable across the diorite intrusion for a distance of 10 chains. The crop is widest in the west, where there is 15 ft. of silicified country, jasperoid, and gossan with copper stains but over the remaining part it is less than 2 ft. wide. As rich ore cropped in the central part, the main underlie shaft was sunk there. This is 140 ft. deep and is connected by drives at 50 and 100 ft. depths with shafts 160 ft. to the west and 124 ft. to the east, these drives extending 100 ft. beyond the western shaft. The workings are now flooded to the top level, but the lode is said to have been between 2 and 3 ft. thick on the average and in the western drive to have opened out to a width of 16 ft. An inspection of the shaft showed me that just above the water the lode is 2 ft. 6 in. wide, and that it has quartz predominating in the footwall half, the remainder being chalcocite and gossan.

No. 1 lode is remarkable for its high silver content, some of the samples from the 50-ft. level having yielded more than 250 oz. per ton, the average over a length of 242 ft. on that level being 53 oz. with copper 11¼ per cent., and a mean width of lode of 2 ft. 9 in. Full shipments have not been recorded, but one parcel of 8 tons sent away last year contained:—

Cu = 24 %; Ag = 118 oz. per ton.; Au = trace; Pb = trace; and Fe = 14 %.

The total shipped between May, 1913, and the end of January, 1914, was 13 6/20 tons of ore, containing:—

Cu = 25¾ %; Ag = 84 oz. per ton; and Au = 2 dwt. per ton.

There is still about 250 tons of gossany seconds, expected to yield 10 to 15 per cent. copper, paddocked at the main shaft.

No. 2 Lode has been traced for only about 4 chains, but to the westwards it may be continuous with No. 2A, here treated separately. An underlie shaft has been sunk on the lode to a depth of 182 ft. and has drives east and west: 100 ft. at 76 ft. depth and 50 ft. at 158 ft. depth. The formation is said to be 4 ft. to 4 ft. 6 in. wide and the dumps show that in depth it

consists chiefly of kindly bluish gossan with bands of chalcopyrite, a little siderite, and veins of quartz. Secondary enrichment is also apparent in pyrite blackened with copper sulphide from the 105-ft. level containing:—

Cu=69 %; Ag=22 oz. per ton; and Au=4 dwt. per ton;

while another sample of "black oxide" from 86 ft. depth yielded:—

Cu=71 %; Ag=2½ oz. per ton; and Au=nil.

No. 2 lode is much lower than No. 1 in silver, though one consignment, made in July, 1913, gave:—

Cu=33½ %; Ag=83 oz. per ton; and Fe=17½ %.

The ore, though much higher in copper, also carries zinc, a parcel of 40 tons from the opencut yielding:—

Cu=34 %; Ag=3 oz. per ton; Au=1 dwt. per ton; Zn=8 %; and Fe=14½ %.

The seconds paddocked amount to 150 tons and are expected to yield up to 15 per cent., but there is besides 50 tons that may give 10 per cent. copper. The thirds, 50 tons in amount, will, perhaps, go 5 per cent.

No. 2A Lode, to the west of No. 2, has a slightly oblique strike. The crop extends for about 2 chains only, but it is unusually prominent, 10 ft. width of cavernous jasperoid standing well above the surface. In an opencut the jasperoid can be seen to contract downwards, but the footwall diorite is kaolinised for 5 ft. and is stained and veined by green carbonate of copper. It is recorded that the lode in the bottom of the opencut showed glance containing:—

Cu=63 %; Ag=7½ oz. per ton; and Au=nil.

Some unrecorded quantity of rich ore has been shipped from here.

No. 3 Lode has a length of outcrop of 5 chains and is believed to continue 3 chains further to the east than it shows on the surface. Over a distance of 120 ft. it averaged 18 in. in width and showed an assay:—

Cu=15 %; Ag=5 oz. per ton; and Au=1 dwt. per ton.

An underlie shaft sunk to 100 ft. depth is now flooded to about 45 ft. below the brace. The gossany lode-formation, which at the water is slightly under 2 ft. thick, carries glance, but further up the shaft malachite and tile ore take its place. Upwards the lode gradually increases to a maximum width of 4 ft., and comprises quartz and gossan with rich bunches of copper ore. The 75-ton heap of quartz-bearing gossan at this shaft should yield at least 5 per cent. copper.

No. 3A crop has a length of nearly 4 ch. and a width of up to 30 ft. It is a formation of quartz and gossan, and carries little or no copper above the 40-ft. level. The shaft is 75 ft. deep and the 50-ft. drive east has been prolonged till it broke through to the surface of the hill and now serves as an adit. The lode, in the first 20-ft. section of the adit and on an average width of 12 in., gave on assay:—

Cu=7 %.

The formation of the upper part of the shaft is 5 ft. wide but gradually increases to 7 ft. at 40 ft. depth, but decreases again to 5 ft. on the 50-ft. level. At the shaft bottom a drive

PHOTO. 9.—SHAFTS NOS. 3A, 2, AND 1, FROM NO. 5, ORTONA.

runs 80 ft. from the shaft to the south-west, passing out of cupriferous formation only towards the end. East-north-eastwards a strong gossany formation, having an average width of 5 ft., is followed. Nodules of glance are scattered through this formation; and there is paddocked at the adit about 50 tons of kaolinised diorite, stained with blue and green carbonates

and containing some dense glance. This should yield between 5 and 10 per cent. copper, and the whole dump of, say, 300 tons will probably run 3 to 5 per cent. copper. Some 35 per cent. ore has been despatched from here and sorting is still practised at intervals.

No. 4 crop is a short one, little more than 2 ch. being exposed. Where untouched, in the west, it is 2 ft. 6 in. wide, but in the open-cut in the eastern end it is only 18 in. wide, though the adjacent country is also veined, and at one place, over 6 in. width, it assayed:—

Cu=40 %; Ag=2¾ oz. per ton; and Au=1 dwt. per ton.

Derived from an adit shaft off the end of the cut, there is stacked 5 tons of 25 per cent. ore, with 50 tons of gossany seconds, expected to yield 15 per cent. copper, and 50 tons that may run 10 per cent. The best ore is half and half dense laminated gossan and white crystalline quartz, the former containing the copper as carbonate and chalcocite with a little tile ore. The lode is thus small but of a kindly nature.

No. 4A crop, consisting of gossan-stained quartz, is up to 10 ft. thick and has a length of about 1½ ch. It seems to fray out westwards in the diorite.

No work has been done in the crop, but a crosscut from No. 5 workings intercepts the lode at the 50-ft. level, where it varies between 6 in. and 15 in. in thickness. It is made up of almost barren gossany quartz, but the adjacent country is much veined and kaolinised. Some further prospecting is required here.

No. 5 Lode is exceptional in that, besides nearly 4 ch. length of crop in the diorite, there is some trace of fissuring for 2 ch. eastwards in the slates. The crop in the diorite is 2 ft. wide and consists of ferruginous quartz.

From the 60-ft. shaft a drive runs off for 50 ft. to the west-south-west and another runs 12 ft. to the east-north-east. In the latter the lode has pinched to a leader, but the kaolin of the formation is stained black, and is encrusted with secondary sulphates, so that further driving may locate a new shoot ahead. West of the shaft the gossany quartzose lode gradually increases from 2 in. to 2 ft., but again has been squeezed down in the face. The footwall country for several feet from the drive has been kaolinised and is seamed with thin veins of limonite, which will probably in depth give place to sulphides. The exposure on the whole is disappointing, though it is not denied that there may be possibilities in depth.

It is recorded that to 50 ft. depth the lode averaged 2 ft. in width and carried:—

Cu=14½ %; Ag=2½ oz. per ton; and Au=2 dwt. per ton.

but the 45 tons paddocked in 1907 assayed:—

Cu=46½ %; Ag= 6 oz. per ton; and Au=1 dwt. per ton.

and the ore stacked for the smelter in the same year contained:—

Cu=8 %.

No. 6 Lode is at the present time the main ore supplier and the only one that has been stoped. It has a length on the surface of only about 2 ch., but in an open-cut its width is over 6 ft., of which one-half has been broken down, as it is rich in bunchy glance and malachite. This lode has undergone secondary enrichment to a greater extent even than No. 2, for the end product here is native copper associated with cuprite, and assaying:—

Cu=89.5 %.

A shaft has been sunk alongside the cut and reaches a depth of 146 ft. Drives have been opened at the 40-ft., 76-ft., and 106-ft. levels. The drive at the 40-ft. level extends 32 ft. to the east-north-east on a 5 ft. formation with 6 to 18 in. gossan rich in glance and malachite. On the 76-ft. level the 18 in. gossany ore-body splits just west of the shaft, but both branches may be seen still in the face 67 ft. from the shaft, the hanging-wall branch being 2 ft. wide and the footwall 6 in., the former carrying bunches of chalcocite and the latter malachite.

The branches, having diverged considerably on the 106-ft. level, have been followed by separate drives, the footwall for 127 ft. and the hanging-wall for 149 ft. The 18-in. lode above the former has been stoped up for 25 ft. to 38 ft. out to a point 93 ft. from the shaft, the formation beyond that being small and badly defined. Incomplete assays records of the 106-ft. level show a mean width of 29 in. between the shaft and the end of the north-western stope, and the metal contents:—

Cu=18 %; Ag=2½ oz. per ton; and Au=1 dwt. per ton.

The hanging-wall formation has bulges up to 2 ft. 6 in. thick of rich carbonate-bearing tile ore near the branch. Beyond that it breaks up into two veins, which have been stoped out over a distance of nearly 60 ft. Westwards of the stope for 14 ft. there is showing 2 to 5 ft. of reddish gossan rich in malachite, which, though it carries some quartz, is regarded as bagging ore and is to be stoped. Still further out the kaolinised, gossan-veined formation spreads a good deal and becomes poor in copper.

In the eastern drive (59 ft. long) and its two crosscuts (20 ft. and 9 ft. long) there is exposed kaolinised diorite much veined with gossan and sprinkled with nodules of copper ore, the whole of which is regarded by the management as low-grade smelting ore.

Practically 500 tons of the material raised from the above workings is looked on as ore, being mostly gossan, with a low proportion of quartz and quite 10 per cent. copper as azurite and malachite. A quantity of rich limonite-chalcopyrite-malachite ore has been despatched, and 30 per cent. ore is yet to be picked out of the heap. The bagging ore at grass in 1907 from the north-west stope showed:—

Cu=44 %; Ag=8½ oz. per ton; Au=2 dwt. per ton; Zn=trace; and Fe=15 %.

The total quantity of ore despatched between May, 1913, and the end of January, 1914, was 62 19/20 tons, that yielded:—

Cu=24½ %; Ag=3 oz. per ton; and Au=1½ dwt. per ton.

Included in this was one parcel of 34½ tons, with:—

Cu=22½ %; and Fe=26½ %.

No. 7 crops are very ferruginous and quartzose, but otherwise of an indefinite nature, and so difficult to distinguish from altered country. One of the crops has a length of 6 ch. and the other of 4 ch.; and they are parallel but joined at the western end by a jasperoid formation. At a shallow depth the lode formations have proved disappointing, being there still less defined and very poor in copper. The enclosing diorite country is kaolinised and much veined with iron ore, and there may be better copper values at greater depths.

In driving 170 ft. from an adit only 10 tons of low-grade (10 per cent.) ore was obtained.

No. 1 West crop is not more than 1 ch. long but it is of a soft ferruginous and kindly nature, and there was formerly showing a 6-in. malachite vein assaying:—

Cu=16 %; Ag=3½ oz. per ton; Au=trace; and Zn=1 %.

A shaft, sunk 20 ft. on the lode, yielded 5 tons of siliceous gossan with copper content amounting to about 10 per cent. At the 100-ft. level the lode has been intersected by a crosscut from No. 2 west shaft, where the lode averages 18 in. in width, and is made up chiefly of gossan, some of it cupriferous; and the inference is that at slightly greater depth there will be a considerable increase in the copper percentage.

No. 2 West crop is only 2 ch. long, and of this half has been removed by open-cutting to a depth of 20 ft. The register shows that the lode, where 32 in. wide in the open-cut, assayed:—

Cu = 9 %; Ag = 1½ oz. per ton; and Au = trace,

but much higher copper values, as much as 43½ per cent. in some places, are recorded from below.

An underlie shaft has been sunk about 100 ft. in formation with lenticular bodies of gossan; and drives have been opened, for 84 ft. to the south-west and 42 ft. to the north-east, on overlapping lenses, 1 to 3 ft. in thickness, of quartz ferro-calcite and cupriferous gossan. There is stacked at the mine about 50 tons of this ore that will probably yield 10 per cent. copper, and there is also paddocked 20 tons of 15 per cent. ore from the open-cut.

A 60-ft. crosscut in the footwall passed through several small veins of siderite and one 18-in. gossan-quartz formation before reaching No. 1 west lode. Still another lode has been broken into on the hanging-wall side of No. 1 west lode.

The exploratory work, as far as it has gone, has been decidedly encouraging.

PHOTO 10.—THE ORTONA COPPER MINE.

Showing the Percy River Gorge, with its Enclosing Sandstone Ranges in the distance.

PERCYVILLE.

Percyville is primarily a gold-mining centre. The lodes are mostly small and exploited chiefly for their gold contents; but in some cases (*e.g.*, the Union and Homeward Bound) the concentrates have a value of their own for copper, lead, or zinc. Both lead and copper ores have been won from lodes near by, and bismuth, tungsten, and tantalum ores also are being washed from the auriferous alluvial (of Sandy Creek).

The basement is schist with very numerous interlaminated quartz-felspar (pegmatite ?) veins, perhaps partly segregations from the schists, and certainly partly acid residuals from the underlying granites. There are also prominent dykes and bosses

PHOTO. 11.—GALLOWAY STREET, PERCYVILLE.

The sandstone plateau in the distance is dissected by the Percy and its tributaries.

of acid porphyry, which have had some connection with the copper-ore bodies, while the gold and maybe the lead are more directly associated with the pegmatities, as is, of course, the bismuth and its connate minerals. With special reference to the description below of Dividend Gully it may be noted that small quantities of bismutite and scheelite have been won on the head of Eight-mile Creek, to the east of Percyville.

During the boom period of fifteen or twenty years ago the miners sent their ore to the two local batteries, since removed to other fields. In those days only free gold was saved, all sulphide values going to waste, so that mine development ceased at water-level. Lately the exceptionally rich auriferous copper ore of

the Union has been carted to Forsayth; but, with a view to testing the capabilities of the lodes below the oxidised zone, the Chillagoe Company has decided to erect a 5-head battery with grinding pan and Wilfley table, and in attachment a Mineral Separation flotation process unit.

Belvidere.

On this lately applied for lease very little work has yet been done. One pothole, 7 ft. deep, exposes a galena-bearing gossan lode 2 ft. in width, but this seems to split into two towards the east. Samples of the galena have assayed:

Ag.=35 oz. per ton; Au=3½ dwt. per ton; and Pb=80 %;

and there has been collected about 3 tons of gossany galena-cerussite ore that may run 25 per cent. lead.

The lode is located on the contact of slate and granite, and is worth opening up, though not likely to be a great producer. There are several other small leaders in the vicinity, most of which, as well as the above, were within the Black Eagle lease, now long abandoned.

Boomerang.

The Boomerang crop is easily traceable for a distance of a quarter of a mile, and it is said to appear for a mile beyond either way. The many shafts sunk on it are now all inaccessible, but it would seem from the surface workings that the gold values are concentrated in short shoots. The lode averages about 2 ft. in width and, besides gold, carries a little copper. The ore paddock at the main whip shaft carries:

Cu=3½ %; Ag=3½ oz. per ton; Au=5 dwt. per ton; and Pb=trace;

and it is understood that the concentrate of similar ore has yielded:

Cu=28 %; and Au=2½ oz. per ton.

The mine records show that at 139 ft. depth there is 18 in. ore assaying:

Cu=2½ %; Ag=14½ oz. per ton; and Au=1½ oz. per ton;

but at 142 ft. the gold and similar values dropped suddenly, as below:

Cu=4½ %; Ag.=3½ oz. per ton; and Au=1 dwt. per ton;

and though drives were there opened east and west along the lode, no payable gold ore was met.

Well's shaft, on the western lease, like the others, is inaccessible. On the 150-ft. level the lode was 1 to 3 ft. wide and carried fair chalcopyrite, though poor in gold. There is certainly a good

deal of chalcopyrite sprinkled through the quartz of the dumps, which total at least 150 tons and carry, say, 3 to 5 per cent. copper, with, it is said, 7 dwt. gold per ton.[1] Work was stopped here because of the poverty of the deeper stone in gold.

The Boomerang is a very siliceous ore, but eminently adapted to mechanical concentration.

Brilliant.

On the Brilliant short lenticular gossany ore-bodies, on either side of a large vein of barren quartz, were exploited for their gold content. The Brilliant is mentioned here because near the surface large blocks of malachite were found, but the workings having now caved in, no determination of the exact nature of the occurrence was possible at the time of my visit.

Dividend Gully.

Dividend Gully is given a place here rather for its general interest than for any economic importance attaching to it—the occurrence of the pneumatolytic metals, bismuth and tantalum, being rare enough to warrant description at any time. The gully is a tributary of Sandy Creek, that enters the Percy River some miles below the township.

This is within the contact area, the schistose slates being irregularly seamed with lenses and veins of quartz and felspar of the nature of pegmatite with a great excess of quartz.

The gully has been intermittently worked for alluvial bismutite for many years. Warden Mowbray wrote, in 1881, that rich bismuth was being found in gullies on the Percy River, his assays showing over 72 per cent. of bismuth; and he also records the discovery of a reef carrying the ore in small quantities.

The mineral tantalite occurs in the wash with the bismuth carbonate; and a sample of the mineral, which is in the form of small rounded pellets, was submitted to the Government Analyst, who found it to contain:

Tantalic and niobic anhydrides ..	= 80 %
Manganese oxide	= 10 %
Iron oxide	= 10 %

It is not saved just now because of the difficulty in marketing it; but, were it in demand, it is probable that hundredweights or even tons could be obtained with ease.

[1] The Ortona assay record book has the following entry, interesting because of the high silver indicated :—1902—Ore paddock, average bottom stone, Boomerang—Cu=3 %; Ag=164 oz. per ton; and Au=5 to 7 dwt. per ton.

In the same locality a little wolfram has been got, and one gully claim last year yielded ½ cwt.

Homeward Bound.

As far as can be seen now the crop had a length of not more than 20 ft., and most of that was stoped out or removed open-cast by the early prospectors. The main shaft, which underlies 45° to 60°, is accessible to the 65-ft. level, where water is now standing. The lode there is 18 in. to 2 ft. wide, but below is variable, in some places 4 ft. wide and in others only 8 in.

The ore at a depth is a mixed copper-lead sulphide carrying comparatively high gold-silver values that cannot be recovered by simple milling, as was proved in 1903, prior to which time 157 tons of oxidised ore had been crushed for a yield of 6½ oz. per ton. Some of the first sulphides met bulked:

Cu = 7 %; Ag = 71 oz. per ton; Au = 5 oz. per ton; and Pb = 5 %.

but at about the 100-ft. level assays showed:

Cu = 2 %; Ag = 15½ oz. per ton; Au = 1¼ oz. per ton; and Pb = 13 %.

A little stoping was done by the Chillagoe Company at the 80-ft. level on 12 to 14 in. ore. There is about 100 tons of ore at grass, chiefly crystalline white quartz with included bands and lumps of mica-schist and a few units per cent. of copper and lead sulphides. Also there is 10 or 15 tons, perhaps seconds, in which the sulphides amount to 10 per cent., and consist of pyrite, chalcopyrite, blende, and galena, the copper and lead minerals mostly restricted to the quartz, whereas the other sulphides seem to replace the included country. The ore is likely to be suitable for treatment by the Mineral Separation process, but development has not been sufficient to prove any large tonnage here.

The ore occurs in greisen-veined schists in close proximity to a dyke of quartz felspar porphyry.

Mountain Maid.

Traces of copper carbonate have been found in the crop of the Mountain Maid, a large dyke of porphyry veined with quartz and gossan. The amount of copper is likely to increase in depth, but probably not to a workable extent. Should, however, the deposit ever be exploited for its gold content the cupriferous concentrate will be of value as a by-product.

Perseverance.

The reef has been worked along the surface almost without a break for over a quarter of a mile; but it is small, the ore-

bearing portion only 9 to 18 in. wide, though the walls in places are 2 or 3 and even 7 ft. apart.

The main shaft was sunk to a depth of 90 ft. by the Chillagoe Company, and in the bottom showed 18 in. quartzose ore, containing over 1 oz. gold to the ton besides a little chalcopyrite. One assay from about 70 ft. depth showed:

Cu = 10 %; Ag = 17 oz. per ton; and Au = 1¾ oz. per ton.

The stone crushed between 1891 and 1900 amounted 522½ tons and yielded slightly over 1 oz. gold per ton, the copper values being lost in the tailings.

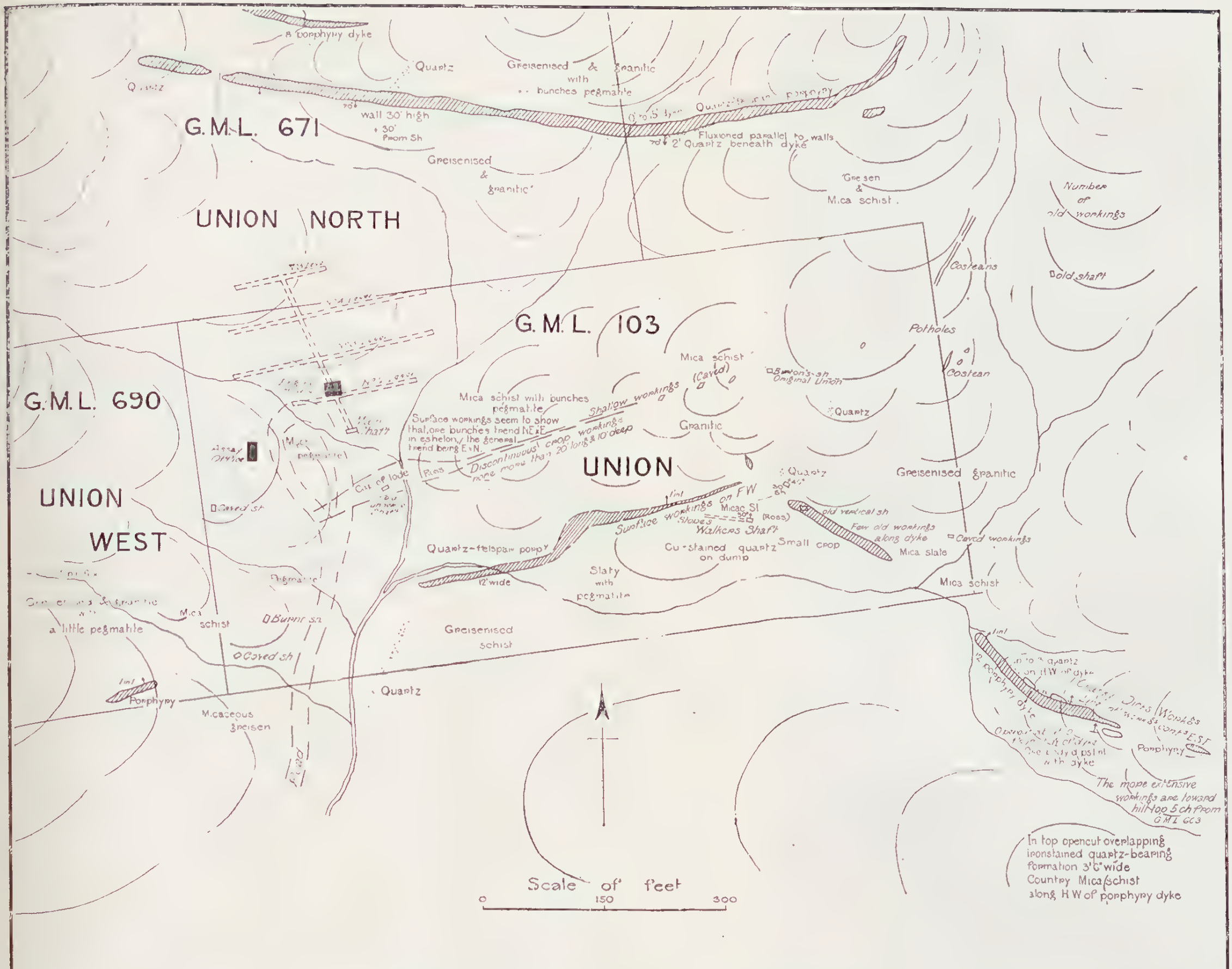
Tunnel.

The Tunnel lode formation is about 4 ft. in total thickness, and of this rather more than half is looked on as ore, the average content being 2 oz. gold per ton. The formation is gossany at the surface and is reported to carry 1 to 2 per cent. copper in depth. The workings have now caved in, but the lode should add something to the output of the field when treatment works are handy.

Union.

The Union lodes are at least three in number, and are known respectively as the Union, Walker's, and Cranky Dick's. Their containing country is mica-schist with irregular greisenised zones and veins of pegmatite, but they are workable only in the vicinity of large porphyry dykes, of which there are several on the property; and it would appear that the copper ores were introduced immediately after the intrusion of these dyke masses, during the period of intense evolution of juvenile waters. The Union lode lies between two of these dykes, Walker's being adjacent to one of them; and Cranky Dick's ore-bodies are strung along another.

The *Union* crop is traceable for, say, 500 ft. as a series of overlapping bunches arranged *en échelon* along a line running out to the east-north-east. The best shoot, that at the western end, has a length below the surface of, perhaps, 300 ft., those to the eastward being seldom more than 20 ft. long at the surface; and none of these last has been followed to a greater depth than 10 ft. The western shoot has been followed 500 ft. to the dip, but with increased depth it is seriously contracting in length. Thus, on No. 3 level the stoping length is 150 ft., but on No. 5 level not more than 60 ft. is of stoping value. The formation of crushed sericitised and silicified granite varies from 2 to 12 ft. in width, but the rich pyritic ore bunches are seldom more than 18 in. wide.



GEOLOGICAL SKETCH PLAN 4—UNION MINE, PERCYVILLE.

Face p. 42.

NATIONAL MUSEUM
VICTORIA

The sulphide ore is essentially chalcopyrite and it is remarkable for its high gold contents. Thus some specimen stone from the stope above No. 4 level west carried the metal in the proportion of 100 oz. per ton. The run of mine ore, after adhering quartz has been knapped off by hand, carries:

Cu = 20 to 25 %; and Au = 6 or 7 oz. per ton;

and the quartz-bearing chalcopyrite seconds will assay:

Cu = 5 %; Ag = 10 oz. per ton; and Au = 1½ oz. per ton.

Of such ore the manager estimates there is 400 tons stacked, and the present monthly consignments may be placed at 22 tons, with values:

Cu = 23 %; Ag = 14 oz. per ton; and Au = 4 oz. per ton;

the seconds corresponding to which amount to 88 tons, containing:

Cu = 2 %.

Mr. Horsburgh has provided me with interesting particulars of consignments from the mine, which total 335 tons. The following is the mean of the analyses given me:

Cu = 20 %; Ag = 14 oz. per ton; Au = 6 oz. per ton; FeO = 25 %; ZnO = 2 %; S = 20 %; CaO = 2½ %; and Insol. = 33 %.

In one parcel containing only 3 per cent. sulphur the insoluble amounted to 80 per cent., exclusive of 7 per cent. alumina; and another extreme return was 10 per cent. insoluble, the ferrous oxide in that case being 32 per cent. Bismuth was looked for and recorded in only one lot of 2¾ tons, and of this the following is the analysis:

Cu = 10¾ %; Ag = 8¼ oz. per ton; Au = 6 oz. per ton; FeO = 21 %; Bi = 0·036 %; S = 13½ %; CaO = 3 %; and Insol. = 52 %.

Walker's crop runs obliquely to the Union and, as mentioned, is separated from it by a porphyry dyke. The crop is not traceable for more than 100 ft., but it has been sunk on for 100 ft., and there are drives at 80 ft. depth, where there are two lodes: one on the hanging-wall and the other on the footwall of the formation, the former being up to 5 ft. in width and the latter up to 2 ft. The Chillagoe Company's explorations do not seem to have been encouraging, though one face assayed:

Cu = 8 %; Ag = 47½ oz. per ton; and Au = 7 oz. per ton.

Cranky Dick's workings are on the contact of a 12-ft. porphyry dyke with the encasing mica-schists. A 3 ft. 6 in. formation has been extensively worked open-cast and in several places sunk on to shallow depths, but these workings have long been idle and are inaccessible owing to caving. There is a possibility of rich cupriferous shoots similar to that of the Union being located below water-level.

GILBERTON.

Gilberton, at one time the gathering place of many thousand alluvial gold miners, is now deserted except for a few, perhaps a dozen, fossickers, who still search the gullies and intermittently work the best of the numerous small reefs hereabouts. Some of these are rich in patches, the Lord Roberts, for example, where some years ago Mr. W. Colley made a discovery of unusual interest—that of gold telluride. Specimens of the ore are said to have assayed 67 per cent. tellurium.

PHOTO. 12.—GILBERTON FROM THE NORTH-WEST.

Commissioner's Hill on the right. Sandstone capped outliers of the Woolgar Tableland in the distance. Note that, except for the Casuarinas along the river, the timber is thin and stunted.

The country is indurated massive bluish slate, tilted at high angles and presumably of great age.

Comstock.

The Comstock, a large gossany crop in the slate country half a mile north of the township, is worthy of passing mention as likely to be metalliferous in depth.

The main crop is made up of limonite, mostly much silicified, but in some places enclosing siderite. It has a length of about 10 chains and an apparent width of 10 to 50 ft., but the width of lode may be much less, and costeans and crosscuts will be required to determine whether there has been surface accumulation.

Other crops along the strike on either end have been picked up, one of silicified gossan to the west being 3 chains long and 10 ft. wide, and another 7 chains long and 5 to 50 ft. wide, out to

the east. The latter in the widest part is made up of boulders of silicified gossan, and, on the dump of a caved shaft just off the crop, there is silicified gossan with ferruginous slate formation.

Though the metal does not occur on the surface, it is likely that copper will be found in the lode towards water-level. Mr. Colley, who carefully sampled all the crops, tells me that the average content is 4 dwt. gold per ton; and the Ortona assay register has two entries, one showing 37½ oz. and the other 16½ oz. silver per ton, with, in the first case, 6 dwt. gold, but none in the second.

ROBERTSON.

Tin, lead, and copper ores have all been won in small quantities in the valley of the Robertson.

Tinstone occurs in the river itself at a point due south of Forsayth.

Lead ores are found in small veins on Robin Hood No. 2 Block, near the mailman's track; and, on the hills overlooking Oaky Creek near Oakville, one or two veins have actually been exploited. Plumbiferous veins have also been noticed on the southern fall of the Rope Walk Range, but these may be regarded as on the fringe of the Mosquito Creek province.

There are said to be large crops of cupriferous jasper on Agate Creek, from one of which a sample assayed at Ortona:

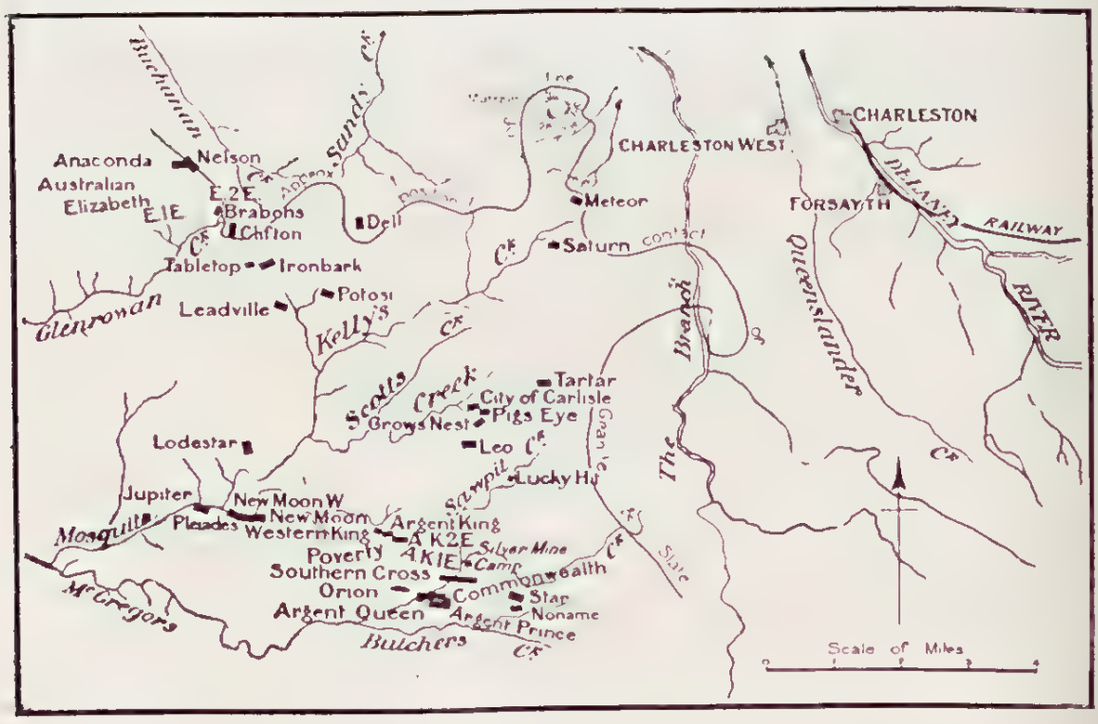
Cu = 2·4 %; Ag = 19½ oz. per ton; Au = 5½ dwt. per ton; and Fe = 2%.

MOSQUITO.

The Mosquito area embraces not only the lead mines on the creek so named, but also those at the heads of Glenrowan and Sandy Creeks and those at the head of the Delaney River; and all these come within the southern portion of the Georgetown-Forsayth lead belt.

Passing notice only can here be given to mineral leases of the granite country in the vicinity of Castleton and Charleston. These include: After All, Argentum, Bountiful, Combine, Ivanhoe, King of the Ranges, Last Hit, Manuka, Midget, Milkmaid, Mount Duval, Problem, Queen Cross, Stockholm, Telephone, Trafalgar, Tragedy Queen, &c., and the lately worked Dry Hash.

The chief silver-lead producers are to the west and south-west of Forsayth. Of most of this group some account will be



Sketch Plan 5.—Mosquito Silver-Lead Holdings
(Topography by T. R. Geraghty, B.E.)

found below, but at the time of my visit only the Commonwealth, Dell's, Poverty, and Southern Cross Extended were being exploited; and little or no benefit from the mining engineer's aspect is derived from a visit to most of the others.

The holdings are naturally grouped as below:—The chief lodes are those on Macgregor's Creek (often loosely described as Mosquito Creek) and Lower Mosquito Creek, those on Glenrowan and Buchanan's Creeks being of no promise. The Argent Queen, Orion, Southern Cross, and the New Moon lines either have been good producers or are likely to become productive of mixed sulphides in depth; but several of the others not seen by me are reported to be of large size, *e.g.*, Lode Star and Meteor, and further developments may be expected if true descriptions have been given of them.

The Mosquito Creek formations are sometimes several feet in width, and outcrops can in some cases be picked up over distances of several hundred feet. At the same time, it has not been proved that the ore shoots have any great horizontal extent. It is remarkable that none of the Mosquito ores are contaminated with bismuth; and, except at the Lucky Hit, gold is present in only small quantity.

For the benefit of strangers desiring to visit the field, some mention is made below of all holdings, even though the author may not be in a position to write from personal knowledge in every case. Many references will be found below to the Etheridge Assay Register: for the figures quoted I am indebted to Mr. A. E. de Lautour, the manager of the Etheridge Mines.

Buchanan.

Two copper lodes, the *Anaconda* and the *Nelson*, have been discovered in the contact country near the head of Buchanan Creek. They have not been worked and nothing is known locally about them, but leases have been surveyed and the ground could, if desired, be located.

The intermixture of granite and greisenised metamorphics hereabouts testifies to the intensity of the igneous action, and it is therefore not surprising that alluvial tinstone has been found in the creek bed.

Glenrowan.

Two of the lodes of Glenrowan Creek, though in a different catchment, belong to the Buchanan Group. These are *Brabon's* and *Clifton*, both of them in the schists quite close to the granite contact. They have been worked for gold; but there is no likelihood of their yielding any quantity of copper ore.

Elizabeth.

The Elizabeth, with it numbers including the *Australia,* are in diorite but within the slate terrain. There is a succession of small crops on a west-north-west line, offering little inducement to the prospector; but two small outcropping lodes on the Elizabeth have been sunk on to depths of 30 and 35 ft. In the shafts there are 12 to 18 in. indefinite ferruginous formations of little or no promise, in spite of the fact that shipments of ore have been made. The first parcel of 3¼ tons was despatched in March, 1912, and contained:

Cu = 15½ %; Ag = 5 oz. per ton; and Au = 2 dwt. per ton.

Another of 29¼ tons, presumably seconds, was sent away in May, and yielded:

Cu = 8½ %; Ag = 3 oz. per ton; and Au = nil.

To the east of Glenrowan there is a scattered group of four lead lodes on which leases have been surveyed. They are the *Ironbark, Leadville, Potosi,* and *Tabletop,* all trending roughly east-west as usual in the slates. At the Leadville diorite and porphyry are found in the vicinity, and may have had beneficial effects on ore deposition. I am not aware that any of these lodes has been worked.

Lower Mosquito.

At and about the junction of Tin Hut and Mosquito Creeks a number of lodes have been pegged out. The country is slate, schist, and quartzite, with crops of diorite not far away; and the lodes strike as usual in an east-west direction. The group is thought to be of promise, and I regret that circumstances prevented my inspecting it.

The Jupiter, New Moon, and Pleiades form a series of crops, of which that on the *Jupiter* is untouched. The *Pleiades* has been sunk on to a depth of 60 ft., and a gossany formation 3 to 5 ft. wide has been exposed, but it is said to be poor in galena.

New Moon.

The New Moon has been one of the most productive lead mines on the field, but all that is known is that a shaft has been sunk 70 ft. In 1910 the Warden recorded that 552 tons of ore despatched yielded:

Cu = 4 %; Ag = 90 oz. per ton; and Pb = 41 %.

Lode Star.

The crop, which is in diorite, is said to be 12 to 60 ft. wide, and to consist of dense gossan carrying calcite and galena, the ore on the surface being below the payable grade. Judging from the description, this should be a case for deep sinking.

McGregor's.

The McGregor's Creek group is the most important of the section, in that most work has been done on its lodes and that most of the shipments have come from it. The lodes are arranged in parallel with an east-west trend, and crops can be picked up at intervals for long distances, but no single lode has been definitely proved to continue for more than a few chains. The area is one of altered slates, and in the southern part these are distinctly thin-bedded, but in the northern part a schistose structure has been superimposed, and in the same part there are numerous areas of diorite.

Two of the holdings, the *Noname,* and the *Star,* were not visited by me. On the former two shallow shafts have been sunk, the product being 8 tons of ore.

Argent Prince.

On the Argent Prince a shaft has been sunk 90 ft., but on the surface there is little sign of lode in the mica-schist that forms the country rock, and the leader must be very small. A parcel of 8½ tons from this shaft contained (according to the Etheridge Mines Assay Register):

Ag = 46½ oz. per ton; Au = trace; and Pb = 50½ %.

Argent Queen.

The lode appears at the surface for about 8 chains, but is not in any way striking, though there is 5 ft. width of formation in the cut between the shafts.

However, the Chillagoe Company sank two underlie shafts, 90 ft. and 125 ft., on it about 80 ft. apart, and connected them below, extending the drives a total of 120 ft. It is believed that the shipments amounted to some hundreds of tons. The seconds, consisting of siderite and blende, are stacked at the mine; and they may be of value at some future time. The workings were not in a fit state for examination at the time of my visit.

Commonwealth.

The main line makes little crop, and that without continuity, but the lode has been sunk on to a depth of 80 ft., *i.e.,* to water-level. Near the surface there is a 5-ft. formation, through which are scattered bunches of oxidised lead ore. In 1907 there was sent away 5 13/20 tons ore, containing:

Ag = 62 oz. per ton; and Pb = 65 %.

This formation has been driven on for 10 ft. at the 35-ft. level

and for 20 ft. at the 80-ft. level. On the latter there is a 3-ft. slaty formation including 12 to 18 in. crushed black country. If this were driven and sunk on it is most likely that other bunches or shoots of ore would be struck.

A second formation of similar size but with galena and blende was discovered 16 ft. away by crosscutting; and some further development is called for.

In places the lodes seem to degenerate into thin bedded veins. This is so in McGregor's Creek, where some small bunches of ore have lately been uncovered.

Hen's Nest.

Along the abandoned line at Silver Mine Camp four shafts, spaced at chain intervals, have been sunk about 30 ft., and the lode between them has been stoped to the surface. The formation is about 18 in. wide; and it is in decomposed diorite.

It is said that a total of 50 or 60 tons of firsts has been shipped, and there is 30 tons of seconds at grass. From the Etheridge Mines Assay Register it is learnt that one of the parcels shipped assayed:

Cu = 0·2 %; Ag = 79 oz. per ton; Pb = 63 %; FeO = 6 %; Bi = nil; and Insol. = 5 %.

Orion.

The crop has been traced and potholed for a distance of 6 chains, and a now inaccessible shaft has been sunk 140 ft., the greatest depth on Mosquito. Heavy water was encountered at 126 ft. depth, and this was strongly charged with sulphuretted hydrogen. The mine has been deserted some time.

It is said that there is an average of 12 in. galena in a 4-ft. formation. Some 300 tons of ore, assaying

Ag = 70 oz. per ton; and Pb = 72½ %,

has been sent away, and there is 150 tons of pyritic seconds (blende and galena, crustified with siderite) at grass.

Southern Cross.

The Southern Cross lines live eastwards for three quarters of a mile from McGregor's Creek. At the creek bank the crop of the gossany formation is 3 ft. wide, but the footwall country is much ironstained for 3 ft. from the lode.

The Chillagoe Company's shaft is 80 ft. deep, with drives at 30 ft. depth 155 ft. long and at 70 ft. depth 95 ft. long. A large tonnage of ore has been despatched (1,000 tons, it is estimated,

from this and the Argent Queen Mine); and there is now dumped at the shaft 300 tons of pyritic ore, besides some tons rich in blende and containing a little galena and siderite. The following returns are quoted from the Etheridge Mines Assay Register as indications of the ore's composition: (*a*) Lead sulphide firsts, amounting to 13 tons—

Ag = 55 oz. per ton; Au = nil; Pb = 68 %; FeO = 4 %; S = 11½ %; and Insol. = 4 %.

(*b*) Lead sulphide seconds, amounting to 6½ tons—

Ag = 35 oz. per ton; Au = nil; Pb = 41½ %; FeO = 10½ %; S = 7½ %; and Insol. = 14¾ %.

(*c*) Tributers' firsts, 8 tons—

Cu = 0·5 %; Ag = 53 oz. per ton; Au = nil; Pb = 63½ %; FeO = 9¾ %; Zn = 1¾ %; S = 8 %; and Insol = 7 %.

The mine was nearly full of water at the time of my visit.

At Leowald's claim, known as the Southern Cross Extended, is the present best showing at Mosquito. The shaft is 85 ft. deep, and at 78 ft. depth there is a total length of driving of 238 ft. (97 ft. of this being along the unstoped footwall lode). At the 30 ft. level there is 50 ft. length of driving. The ore has been stoped out for from 12 ft. (at the surface) to 35 ft. (at the bottom level) to the east of the shaft, and from the 40-ft. level on the west a stope on the hanging-wall lode gradually opens out to a total of 50 ft. from the shaft at the 78-ft. level.

Photo 13.—Leowald's Southern Cross Extended.

The formation at the surface was 3 ft. 6 in. wide with 9 to 24 in. width of solid galena. At the 40-ft. level there is 18 in. galena showing, and the formation on the 78-ft. level is 18 in. wide, and any part or the whole of this may be lead-bearing. Since December, 1910, Mr. Leowald has sent away from the mine 277 tons of firsts assaying:

Ag=44 oz. per ton; and Pb=68 %.

and 255 tons of seconds, assaying:

Ag=13 oz. per ton; and Pb=24 %.

At the time of my visit he had 15 tons bagged ready for shipment, and estimated to contain 73 per cent. lead.

Marquis.

The Marquis, on the northern extremity of the slate promontory with intrusive granite on three sides, would naturally be regarded favourably as a locus for ore deposition, and it has actually yielded the miner a good deal of gold. Three metalliferous lodes also have been considered worthy of appropriation by leasing. One of them, the *Saturn*, has been sunk on 70 ft., but nothing has been shipped from it. Another, the *Enigma*, is in the granite country to the north.

Meteor.

This is reported to be "a big ironstone lode," 9 to 13 ft. wide, and some encouraging results came from the little work done by the Mosquito Creek Prospecting Company. A shaft was sunk in gossan and galena to water-level at 62 ft., and a drive was then opened in a big formation with 3 ft. width of gossan, but as it contained no galena, the mine closed down.

On the assumption that the above is a true statement of affairs, this would seem to be a case for deeper sinking in search of lead and possibly other sulphides.

Sandy.

Sandy Creek flows northwards from the Mosquito Creek watershed, which here is the boundary between the slate and granite areas. Several gold reefs have been opened up on Sandy Creek, and there is one lead show at its head deserving of separate mention.

Dell's.

Dell's lode differs from the majority in the Mosquito area in having granite as its country and in striking northwards. It

differs also in the nature of its ore, a dense limonite with bands of earthy gossan and patches of glassy cerussite into which the limonite gradually shades. There has been some slight silicification with the production of jasperoid.

The better part of the crop is 8 chains long, but it persists, with possibilities of downward improvement, far out to the south-east. In one pothole the crop is seen to be 12 ft. wide, and of this the greater part is gossany.

Photo. 14.—Dell's, Sandy Creek.

The main shaft is 35 ft. deep. This shows foot- and hanging-walls 5 ft. 6 in. apart; there being between them 2 ft. of kaolinic formation on the footwall, then 18 in. limonite and cerussite, and on the hanging-wall 2 ft. width of white quartz. The complete production cannot be stated, but there are records of one parcel of 10½ tons lead carbonate firsts, of which the following is the analysis:

Cu=0·2 %; Ag=17½ oz. per ton; Au=4 dwt. per ton; Pb=45½ %; FeO=13½ %; Bi=nil; and Insol.=15 %;

and another of lead carbonate seconds—5½ tons—containing:

Cu=0·1 %; Ag=9½ oz. per ton; Au=5 dwt. per ton; Pb=30½ %; FeO=19½ %; Bi=nil; and Insol.=27 %.

Sawpit.

Sawpit Creek is a tributary of McGregor's Creek, coming down from near the head of Mosquito Creek. Its lodes really belong to the Upper Mosquito Creek group, for they are in the same area of extreme metamorphism, wherein the country has

developed a high degree of schistosity. Pegmatite veins and masses are very frequent, proving that the granite batholith can be at no great depth in this place. Large crystals of schorl are developed in some of the pegmatite as well as a little monazite.

Leo.

On the Leo there are at chain intervals a 14 ft. shaft, a 23-ft. shaft, and a 41-ft. shaft, the last with a 12-ft. drive. The lode is reported to be small and poor; and the ore production has been only 1½ tons, of a value of £7 or £8, its analysis being:

Ag = 15 oz. per ton; Pb = 30 %; FeO = 12 %; Bi = nil; and Insol. = 39½ %.

Lucky Hit.

Cameron's Lucky Hit, one of the few lodes now being worked, is in greisen-veined mica-schist close to a mass of pegmatite. It has not been traced any distance on the surface, but a shoot of ore has been stoped to a depth of 45 ft., the horizontal length of the stope being 15 ft. The walls of the formation are 3 ft. apart, but only 12 in. of this is strongly plumbiferous.

The ore is exceptional in that it contains appreciable gold values. More than 100 tons of ore have been despatched from the mine, with:

Ag = 25 to 35 oz. per ton; Au = 6 to 7 dwt. per ton; and Pb = 35 to 40 %.

The following analysis (from the Etheridge Mines Assay Register) is that of a 6½-ton parcel sold:

Cu = 0·12 %; Ag = 30 oz. per ton; Au = 7 dwt. per ton; Pb = 57½ %; FeO = 7 %. Zn = trace; S = 7 %; and Insol. = 10 %.

Tin Hut.

The lodes at the head of Tin Hut Gully might be grouped with those of McGregor's Creek, as they are in the same diorite-intruded slate area. In addition to those described below, there is the *Western King*, but that was not visited.

Argent King.

This lode makes little crop, and only shallow trenching has been done on the surface, but a shaft has been sunk 60 ft., and the ore got has been sent away. In 1907, 3 7/20 tons ore was despatched, and this assayed:

Ag = 13½ oz. per ton; and Pb = 49 %.

In 1912 there was a shipment of 2 4/20 tons, containing

Ag = 26 oz. per ton; and Pb = 62 %.

The country enclosing the lode is a soft blue-black slate, but there is an irregular mass of diorite within a few chains of the crop.

Poverty.

Leahy Bros., on the Argent King No. 1 East, have sunk two shafts 46 ft. apart to depths of 50 ft. and 60 ft. They have stoped out to the 50-ft. level a 12-in. galena-bearing lode for 25 ft. on either side of the old shaft, and they are now opening out drives on either end of the new shaft at the same level, the faces showing 12 to 18 in. galena.

There has been shipped 50 tons of firsts containing:

Ag = 75 oz. per ton; and Pb = 60 %;

and the 15 tons of seconds at grass assays:

Cu = trace; Ag = 45 oz. per ton; Au = trace; and Pb = 25 %.

Upper Mosquito.

This locality has received a good deal of attention from gold miners, both reef and alluvial. The sedimentary rocks are much metamorphosed, for they only just overlie the granite, as is evidenced by exposures in one part of the valley.

City of Carlisle.

There is here an 18-in. gossany formation in mica-schist near an intrusion of diorite. A little ore has been obtained, but there is no promise of large quantities to be won.

Crow's Nest.

The Crow's Nest is a well-defined formation with walls 2 to

Photo. 15.—Crow's Nest from the South-east.
Pig's Eye in the valley bottom and Glenrowan Mountain in the distance.

4 ft. apart and consisting of gossany quartzose ore, including galena and anglesite. It has been open-cut for a distance of 50 ft. up the hillside, and stopes extend further in still, a shaft having been sunk 80 ft. from the crop above. The ore was formerly sought for its gold values, 3-oz. crushings having been got at the old Glenrowan battery, but at the present time it is being mined for its silver-lead contents.

It occurs in slate and mica-schist exhibiting some degree of greisenisation. In the vicinity there are also dykes of porphyry and diorite, and within a quarter of a mile the granite batholith crops.

Pig's Eye.

The Pig's Eye has been worked over a length of 75 ft., but the shafts have all caved in. The formation, which is 2 to 4 ft. wide, is mostly white kaolin, but there is some quartzose gossany crustified lode material, and vesicular gossan was met in the last shaft sunk. At the beginning of 1913 a parcel of 3 tons was shipped *viâ* Forsayth, and this had the following composition:

Cu=0·2 %; Ag=33½ oz. per ton; Au=trace; Pb=70 %; FeO=7 %; Bi=nil; S=8 %; and Insol.=3½ %.

The country is mica-schist, but there is a large greissic granite crop only 4 chains from the lode, with which its edge runs parallel.

Tartan.

This lode is also known as the Rhino. It is small, but owing to induration of the adjacent country it makes a prominent crop, which has been followed for 1½ mile. In a shaft, 25 ft. deep, there can be seen 5 in. quartz on the footwall and 8 in. dark cellular gossan on the hanging-wall. The prospectors shipped 5 tons of ore, and there is paddocked 10 tons of ochre-stained honeycombed gossan, with some partly decomposed siderite.

OAK RIVER.

The Oak River drains into the Copperfield and is on the eastern fall of the Newcastle Range; but it is here included because the copper mines near its head are possible sources of freight for the latest proposed railway—that down the Robertson—the construction of which would directly simplify their transport problem. Hitherto Einasleigh has been the railway shipping point.

Great Eastern.

The ore deposit, which is of indefinite form and low in copper, is in granite near an outcrop of porphyry. It is understood that the shaft is 90 ft. deep and that heavy water was encountered.

Thorn's Find.

The country here is mica-schist with intrusions of diorite and later segregations of aplite and pegmatite. There is no very persistent crop, but copper ore has been found in the diorite, and on its contact with the schist, over a space of 2 chains.

In one open-cut there is showing 18 in. gossan and quartz with some stains of copper, and 2 cwt. of 5 per cent. ore has been set aside. At another there is stacked 2 tons of rejected quartzose gossany ore with about 10 per cent. copper carbonate as stains, veins, and impregnations; and also 2 tons of quartzose gossany seconds with malachite amounting to 15 per cent. There is in this cut a 2-ft. body of quartzose, copper-stained, cellular, red gossan.

Three shafts have been sunk: one, 40 ft. deep, is in hanging-wall country still; a second, 50 ft. deep, passed through a flat band, 8 ft. thick, of slightly ironstained glassy quartz, separated from the schistose diorite below by 18 in. width of pegmatite, and for 5 ft. above the quartz there are bunches of cellular gossan in the decomposed diorite; and a third, which is vertical for 12 ft. and then underlies 1 in 1 east-by-north for 28 ft. In the upper part of this is a body of cellular gossan, 4 ft. wide in one part but going out downwards, its place being taken in the bottom by 18 in. ironstained quartz, with only patches of cellular gossan, in contact with a thin vein of pegmatite. The lode has a strong footwall.

The close association of ore and pegmatite is noticeable, but, while new ore-bodies may be located along the crop of that rock to the south of the workings, the diorite is more likely to have effected the actual precipitation of the copper minerals, and prospecting is more likely to be prolific in its vicinity. Some further development is certainly warrantable.

18th February, 1914.

ANTHONY JAMES CUMMING, Government Printer, Brisbane.

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Queensland.

DEPARTMENT OF MINES.

Queensland Geological Survey.

PUBLICATION No. 246.

The Einasleigh Freehold Copper Mine, N.Q.,

WITH 1 MAP, 9 PLANS, 1 GRAPH, AND 8 PHOTO PLATES.

BY L. C. BALL,

ASSISTANT GOVERNMENT GEOLOGIST.

BRISBANE:

BY AUTHORITY: ANTHONY JAMES CUMMING, GOVERNMENT PRINTER.

1914.

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Plate I.

THE EINASLEIGH MINE.

With the township in the distance on the right, as viewed from adit to the north; showing also the junction of the Copperfield (coming in from behind the mine) and the Einasleigh (in the foreground), the basalt coulée on the edge of which is the main shaft, and the aplite- and amphibolite-veined schists in the bed of the river with the outcrop of the new basic ore-body in the middle of the foreground.

INTRODUCTION.

The Einasleigh mine, the premier copper producer of the Etheridge Mineral Field and a mainstay of the Chillagoe Company, is located on the junction of the Einasleigh and Copperfield Rivers, in latitude 18° 32′ S. and longitude 144° 6′ E. A short spur links it up with the Etheridge Railway (from Alma-den to Forsayth), which comes within half a mile of the mine. The railway station, called after the mine and township, is 101 miles from Alma-den (the junction with the Chillagoe Railway, and distant 120 miles from Cairns, its shipping port), and its elevation above sea-level is 1,478 ft.

The writer spent ten days at Einasleigh towards the end of last year, and has to acknowledge the many courtesies extended by Messrs. J. Horsburgh, general manager of Chillagoe Limited (mines and reduction works), and W. Smith, local manager of the Einasleigh Mine.

History.[1]

Copper ore was discovered on the Einasleigh by Mr. Richard Daintree at a time when the river was believed to be the Lynd; and the workings were accordingly dubbed the Lynd Copper Mine, a title that, though officially altered in due course, clung for many years. Daintree himself wrote a description of his mine for the Royal Society of New South Wales in 1867. The proceedings for that year are not available to me, but Dr. Jack, writing in 1898,[2] quotes Daintree to the effect that a shaft had been sunk in 1867, and that a drive at the 30-ft. level showed the lode to be 23 ft. in width and to consist of spongy metallic copper. Dr. Jack concludes that "even 'metallic copper' in the remote region in question it appears could not be mined and transported with profit," whence we may assume that very little ore was despatched from the mine. At the time of Dr. Jack's visit in 1898 the mine was deserted.

It is recorded in the Annual Report of the Department of Mines for the year 1900 that the Einasleigh Freehold Copper

[1] The history of this mine has been most imperfectly recorded and the writer has laboured under the further disadvantage of not having access to the early descriptions of Mr. R. Daintree or the recent private reports of Mr. Savage and Dr. R. L. Jack.

[2] Report on the Chillagoe Mining District and Projected Railway. G.S.Q. Publication No. 134, p. 20.

Mines, Limited, was working systematically and erecting machinery, including winding gear and water-jacket blast furnace, to cost £12,517. In the following year this company, employing 70 men, smelted 1,009 tons of ore for a yield of 101·616 tons of copper (or 10 per cent), containing 1,330 oz. silver (or 13 oz. per ton of ore) ; but early in March, 1902, work ceased, and the mine remained idle till 1907, when the company was reconstructed, and came forward as the New Einasleigh Copper Mines, Limited. The output for the year was but 12 tons 6 cwt. of 1¼ per cent. ore.

Next year, under the management of Mr. H. G. V. Adler, a start was made to open up No. 3 level. The number of men employed was 50, and during the year there was shipped about 20 tons of 4½ per cent. ore, besides which it is to be presumed large additions were made to the stocks at grass. Mr. W. E. Cameron, of the Geological Survey staff, inspected the mine early in this year. The main shaft was then 204 ft. in depth, but the mine was still in the prospecting stage and being systematically developed.[3]

During 1909, the number on the pay roll increased to 105, and shipments showed a sudden inflation, the total despatched to Chillagoe being 10,913½ tons of ore. A most elaborate plant (including an Elmore flotation unit) for the concentration of the siliceous sulphides was erected in 1910, but for sundry reasons it proved a failure, and consignments continued to go forward to the smelters, this year's total being 20,210 tons.

In 1911 the Chillagoe Company bought the property, and brought the total production for the year to 15,793 tons. For 1912 the ore despatched amounted to 24,418½ tons.

The mine in 1913 became the chief source of supply of copper ore for the Chillagoe smelters, but this was indirectly the cause of its undoing, for, in order to keep up with the smelters' requirements, development was neglected, and, towards the end of the year, the daily production fell to one-half of what had come to be regarded as the normal. The output for the first ten months of the year reached a total of 22,480 tons of ore.

From recent Press notices it is learnt that the Chillagoe Company is pushing forward development in the lower levels, and, as part of the campaign, the sinking of the main shaft is to be resumed.

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[3] Second Report on the Etheridge Goldfield. G.S.Q. Publication No. 19, p. 19.

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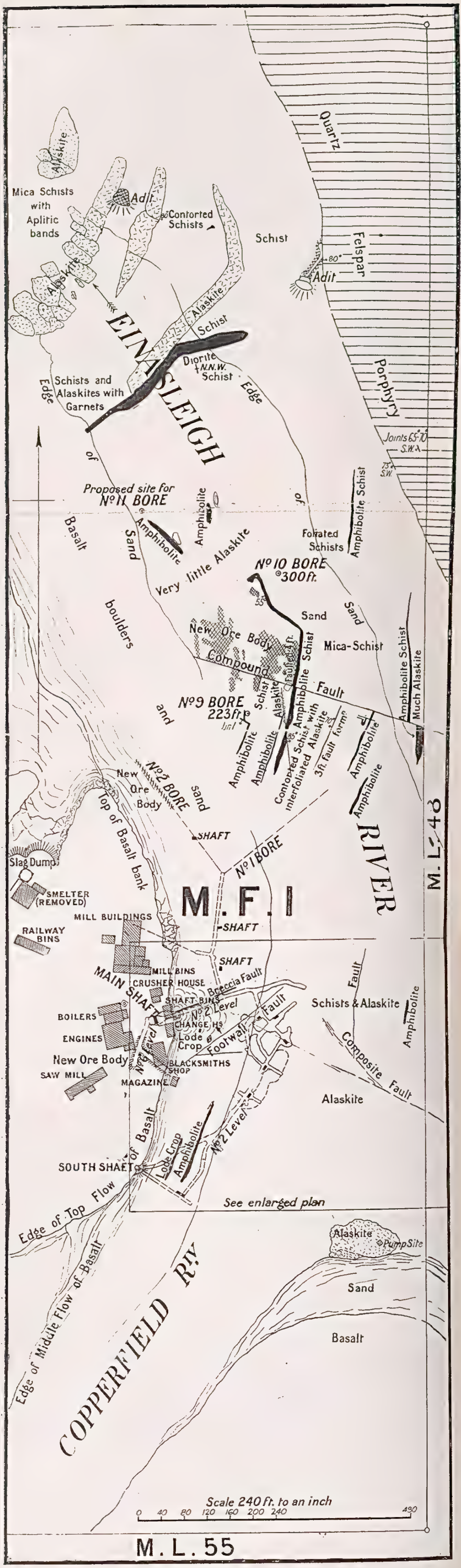

EINASLEIGH FREEHOLD COPPER MINE.

Geological Sketch Map.

Literature.

The first account of the mine was written for the Royal Society of New South Wales in 1867 by the discoverer, Mr. Richard Daintree.

Dr. Jack visited the then deserted mine in 1898 and saw the outcrop, his description [4] of which is quoted elsewhere.

In his second report [5] on the Etheridge Goldfield, written in June, 1908, Mr. W. E. Cameron has a brief paragraph on the Einasleigh Copper Mine.

Mr. E. O. Marks, late Assistant Government Geologist, gave the first official account [6] *in extenso* of the mine, together with a geological plan of the vicinity. He showed that the country rock is gneissose schist and that the ore occurs in separate lenses with their longer axes parallel to the strike of the country rock. The ore is described as a mixture of pyrites, pyrrhotite, and quartz, with garnets occasionally present, and a considerable amount of hornblende, and a little calcite and gypsum. He advises prospecting for fresh and perhaps deeper ore lenses to the east of those already found.

GEOLOGY.

The rock basement in the vicinity of the Einasleigh Mine is extremely complex, comprising as it does dark mica-schist or gneiss and variously shaded quartzites, with lighter coloured segregated masses of quartz and felspar and dykes of aplite or alaskite, besides dykes of amphibolite, the last crushed in places to such an extent as to be only with care distinguished from the mica-schist. The field relationships prove that the original sedimentaries after tilting were intruded by basic dykes, and subsequently submitted to compressive stresses causing recrystallisation and inducing a well-marked north-south schistosity. At a still later date the complex yielded under tensile stresses with the production of an east-west fracture system.

The dislocations are simple and well defined where they cross the amphibolite dykes, but in the schists they are apt to become compound, splitting up or branching at frequent intervals. Notwithstanding the formations of brecciated or altered country marking the more open parts of the fissures,

[4] Report on Chillagoe Mining District and Projected Railway. G.S.Q. Publication No. 134, pp. 8 and 20.

[5] The Etheridge Goldfield. G.S.Q. Publication No. 219, p. 19.

[6] The Oaks and Eastern Portion of the Etheridge Goldfields. G.S.Q. Publication No. 234, p. 21.

any great lateral or vertical relative movement of the wall rocks was exceptional, because most of the fissures are discontinuous, giving place to insignificant joint-like breaks or else fraying out and interlacing with other similar fissures. It is to this peculiarity that we must attribute the bunchy form and sporadic occurrence of the ore deposits, for the fissures served as channels along which the metalliferous solutions escaped from below, and it was only where the fissures were large enough to bring in sufficient supplies, and where the schistose country was of the requisite nature for dissolution and replacement, that precipitation could occur.

At some period in general ante-dating the east-west fissuring immense quantities of aplite invaded the schists; and after a probably lengthy period of time came the porphyries, subsequently to the intrusion of which the ores were deposited.

It is a matter for regret that no petrological work has been done on the rocks of Einasleigh, as without microscopical investigation the real nature of both the country and the ores must remain unsettled.

Schists.

The main body of the schistose rock, it is taken, had a sedimentary origin, but, beyond indistinct traces of bedding planes and light cherty bandings, there is little in proof of the supposition, all original structures having been obliterated during the progress of regional metamorphism with its concomitant recrystallisation, which included the production of biotite, garnet, and possibly hornblende and zoisite. The slaty bands on No. 6 plat are found under the magnifying glass to consist of spherically radiating actinolite in a fine-grained base of quartz and felspar.

Quartz, felspar, and mica in granular admixture are the essential constituents of the schists. The mica is the black ferromagnesian variety biotite, and on account of its predominance gives its name to the rock. Both orthoclase and plagioclase felspars are present. Besides quartz the only other microscopically recognised mineral is garnet, which occurs sparingly in indistinct granular aggregates.

The schists owe their structure in the first place to the orientation of the biotite (flakes $\frac{1}{20}$ in. in diameter) and the stringing out of lenticular seams and bodies of granular quartz and felspar passing into aplite. The imperfection of the schistosity in places, as on the hanging-wall of the Big stope below No. 3 level, where there is a strong platy cleavage, is owing to a deficiency of biotite.

Plate II.

Schists with Interfoliated Aplite.

In bed of Einasleigh River to the north-north-east of the main shaft.

Some of the ore carries as much as 8 per cent. lime, and the presence of limestones among the sedimentaries is suspected, but such, possibly because of extreme metamorphism, have not yet been detected. On the other hand, the lime may have been derived wholly from the decomposition of a triclinic felspar.

Amphibolites.

The first or oldest of the intrusives are the amphibolites, of which many small crops appear in the bed of the Einasleigh, all of them exhibiting in some degree a schistosity agreeing with that of the mica schists. The majority of the crops also lie conformably with the schists, but some of the largest cut directly across their strike. They have no great linear extent, and most of them have undergone faulting. In places also there is evidence of projecting corners having been shorn off those dykes originally exhibiting marked departures from the tabular form. They are most erratic in their behaviour towards cross faults and dykes. One branch of a dyke may be continuous on both sides of a joint, while a few inches or feet away another branch may be completely cut off.

Search was made for the amphibolite underground, and it was definitely located on the hanging-wall side of the old ore body at No. 5 level in a position that corresponds with the crop in the bed of the river 220 ft. east of the main shaft. Then again, the blocks raised from the main shaft between Nos. 5 and 6 levels prove that another dyke was intersected below the new ore body. It will also be observed that the pyritic crop in the bed of the river seems to rest in the re-entrant angle of an amphibolite dyke.

An unusual occurrence was observed at one spot in the bed of the river below the mine—the amphibolite and adjoining aplite there having large crystals of wine-coloured garnet. The crystals are up to ½-in. in diameter. They do not appear to have distinct faces, and some of those embedded in felspar are crowded with inclusions of that mineral.

The chief macroscopically recognisable mineral is hornblende, granular crystalline, with grains seldom more than 0·05 in. long but oriented to cause a rough schistosity or a silky fracture in the case of the microcrystalline rock. Felspar and quartz are present in variable amounts. Exceptionally there is only a little clear white granular secondary quartz; again, it may be accompanied by a little felspar or more often ousted by it; and some of the rock has a speckled appearance in consequence. Sulphides also occur as an impregnation in the case of the dyke below the new ore-body between Nos. 5 and 6 levels.

Segregations are not infrequently seen in the amphibolite dykes. They consist chiefly of quartz and felspar, with some crystalline masses of hornblende, and they gradually shade into the main body of the rock. In some parts there has been an excessive development of quartz sometimes extended into vein form, yet not sharply defined from the main amphibolite mass, and besides including a little orthoclase and plagioclase. These segregation masses sometimes carry sulphides, chiefly in the interspaces, and more especially in association with the amphibolite, quartz apparently having been the least effective precipitant.

Basic pegmatites are not uncommon in the schist, and some very coarse examples came from the upper mine workings. In these the hornblende crystals are sometimes 1½ in. long and ½-in. in diameter, and the felspar is found in masses of several pounds weight. It is interesting to note that the larger crystals are orthoclase, and include grains of hornblende, and that the plagioclase occurs sporadically distributed through the hornblende.

The old dumps contain interesting specimens from a segregation patch met in the upper levels. These have coarse crystals of hornblende, ½ to 1 in. long, separated by crystalline plagioclase and quartz with idiomorphs of orthoclase 1 in. long. The felspar includes small crystals of magnetite, and some of the hornblende phenocrysts are speckled throughout with felspar or zoisite.

Aplites.

The second in age of the intrusives is a group of light-coloured, fine-grained, saccharoidal, granitic rocks that may be designated provisionally as aplites. These were regarded as alaskites in the field, and are so shown on the attached maps and plans. As noted on the plan, the rock has been so extensively injected that in parts it bulks larger than the schist.

The larger masses have a finely granular allotromorphic intergrowth of plagioclase and quartz with rare and adventitious specks of biotite, but the smaller bodies are usually more coarsely crystalline, and might better be described as pegmatites. The aplites near the ore-bodies, especially where they enclose bands of mica schist, are sprinkled with chalcopyrite and pyrrhotite; but on the whole the aplite-veined country does not seem to have been favourable for the deposition of copper minerals.

Aplitic aggregations of lenticular form are common. They have a ground mass of granular quartz and felspar, with scattered phenocrysts up to ½-in. long of plagioclase. The latter mineral

Plate III.

THE APLITE DYKES.

With the lower edit and the porphyry range above.

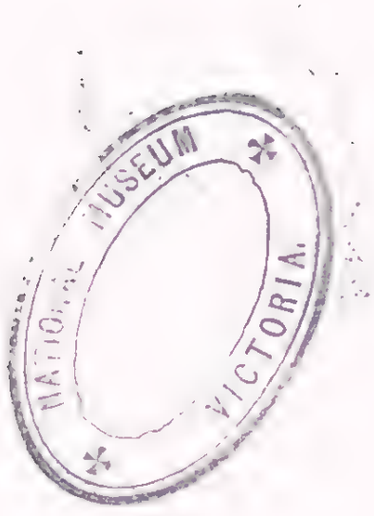
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Plate IV.

THE PORPHYRY DYKE TO THE EAST OF THE RIVER.

Viewed from the mine. Aplite- and amphibolite-veined schists in the river bed.

The new ore-body crops to the left.

from a depth below the surface is bluish, but the orthoclase is glassy white, and sometimes includes small ($\frac{1}{10}$-in.) corroded crystals of quartz, besides having a micrographic intergrowth of the same mineral. The felspar in and near the ore-bodies has net-like growths of chalcopyrite, and is often surrounded by it.

There are also much coarser (pegmatitic) segregations of quartz and felspar in about equal proportion. The felspar comprises both pinkish orthoclase, in crystals up to 1 in. in length with occasional nests 5 in. in diameter, and slightly decomposed plagioclase. Hornblende crystals are seen as well as rare books of mica; and there has often been a tendency to excessive deposition of a single mineral such as quartz.

The presence of large crystals of garnet on the contact with amphibolite has already been noticed. The crystallisation of the garnet and felspar must have been almost contemporaneous, for in some places the minute crystals of garnet are set in the felspar in such a manner as to produce in effect a large crystal of garnet crowded with felspar inclusions.

The aplite occurs mostly in short tapered tabular masses, some of them continuous for many chains, but not everywhere sharply separated from the enclosing schists. There are all gradations between the few crystals in a pocket in the schists or alongside an ore-body, and the dyke 50 ft. or more across. Many of the dykes are quite straight, and usually they trend with the schists, but some, especially the very thin ones, are buckled up in a bewildering fashion, even though the enclosing schists are not in any way contorted. They are in fact the result of interlaminar injection, and they seldom penetrate far into the older amphibolite dykes, nor except in a few cases have they been observed to follow the faults.

That the aplites are older than the ore-deposits is proved by their occurrence in the mine, where their felspar has in some cases suffered replacement by metallic sulphides.

Porphyries.

The dykes of porphyry are the most recent exposed. They are of immense size; and one, up to a-quarter of a mile across, forms a conspicuous range to the east of the mine; but their effect as metamorphosing agencies was slight, if not negligible. This may be well demonstrated where the Einasleigh River cuts through the range, exposing the dyke and the adjacent country.

At this point, which is about a-quarter of a mile east of the mine, it is decidedly constricted, its width in one place

being less than a chain; and there the porphyry has been altered to a dark micaceous, siliceous, and pyritic rock with an indistinct brecciated structure, the cause of which is not quite plain. The conversion of the adjacent schists into chert and hornstone points to mineralising solutions as the agency. Mr. Marks has mapped the dyke, and he concludes that "it is quite possible that the Einasleigh deposits also have some genetic connection with the large porphyry dyke on the eastern side of the river."

The porphyry has a fine-grained pinkish to bluish-grey felsitic base, in which are set small slightly corroded phenocrysts of quartz (0·05 to 0·1 in. long). Orthoclase is slightly less plentiful, in crystals (up to 0·3 in. long), with a nucleus of some greenish-yellow earthy substance. Also scattered through the base there are a comparatively few flakes of a greenish ferro-magnesian mineral, probably decomposed biotite.

The eastern dyke exhibits jointing on a large scale, the plane of the master-joints lying parallel to the contact surface.

Basalts.

The basalt flows of the Einasleigh and Copperfield valleys have elsewhere been shown to follow closely the old river courses, so hiding the underlying metamorphics except where the modern rivers have been able to cut through the sheets and round their edges as at Einasleigh. On the Copperfield, just above its junction with the Einasleigh, the river has cut a well-marked canon, which affords a good exposure of the whole thickness of the basalt, and proves that there were three separate outpourings of the lava. The uppermost sheet is 6 ft. thick and very vesicular. The middle layer, 12 ft. thick, is coarsely crystalline and columnar; and vesicles are scarce except in peculiar flat pancake-like masses of black slaggy lava that may be restricted to its upper surface. The bottom layer is 15 ft. or more in thickness. In structure it is columnar, the columns being 5 ft. in diameter.

Where the top layer has been removed the middle sheet has been potholed on a large scale, some of the holes being permanently water-bearing through the longest droughts. These potholes are perhaps due to mechanical corrasion in part, but chemical decomposition and solution, under the action of the contained weed-clogged waters, is indicated by the contours of many of the smaller holes.

Ground Water.

No. 2 level is stated to be at the mean natural surface of the ground water. In October, 1913, the mine was making 40,000

Plate Va.

THE PORPHYRY RANGE.

From the basalt plain between the Einasleigh and Copperfield Rivers
The Einasleigh Mine on the left

Plate Vb.

The Edge of the Basalt Coulée.

With the South Shaft in the middle distance and the Porphyry Hills across the river.

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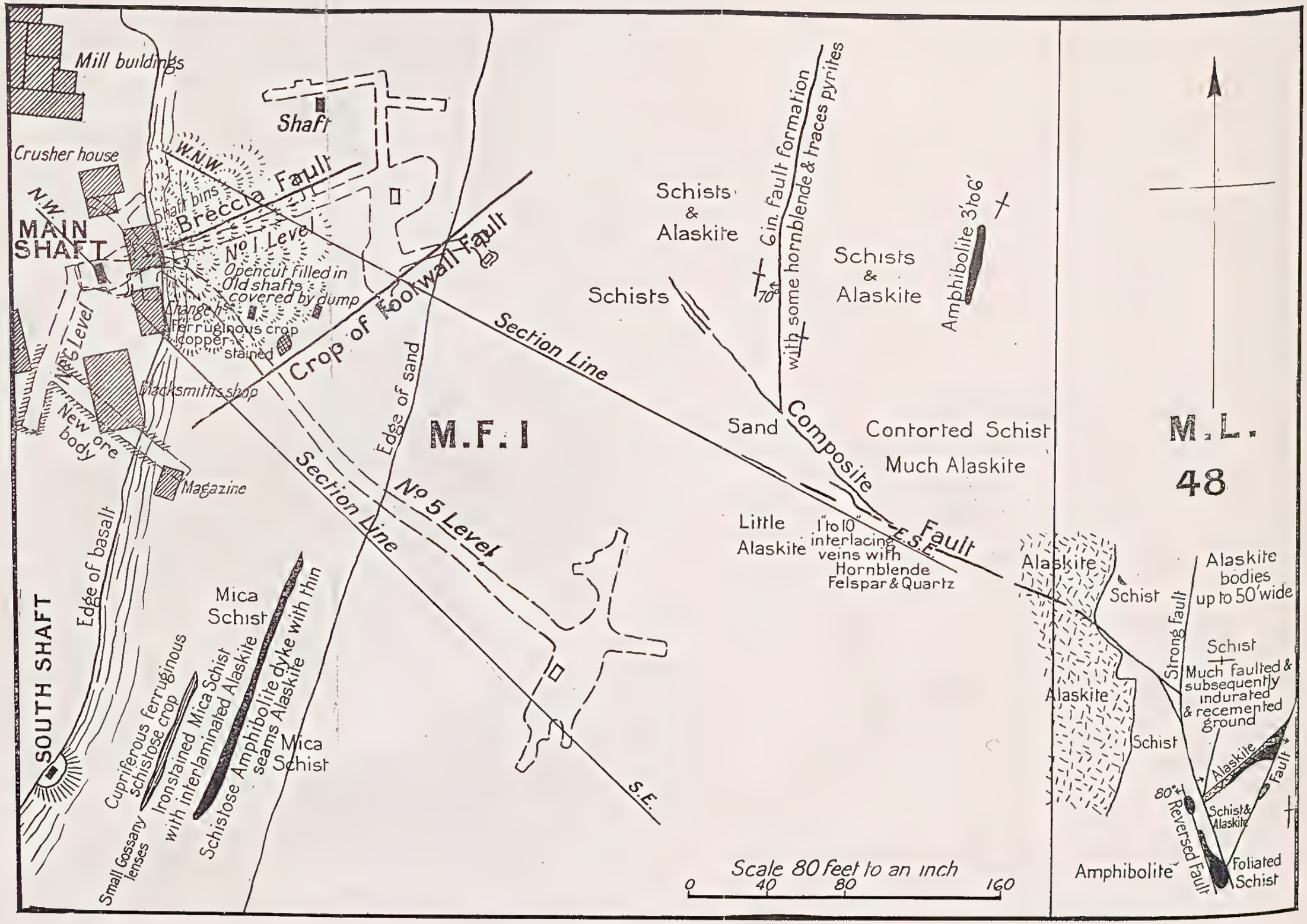


EINASLEIGH FREEHOLD COPPER MINE.
Surface (above Main Workings).

gallons of water per day; and in the wet season the quantity is perhaps 46,000 gallons; most of the additional flow coming from beneath the basalt. This has been regarded as circumstantial evidence that the ore-bodies now being worked underground are not connected with those opened up by Daintree at the surface; and it accentuates the need for constant lateral prospecting during development and the actual breaking down.

Many of the fissures met below the surface have been water-bearing when first struck, and the flow from one fissure on the No. 5 level did not cease until it was tapped in the main shaft below.

ORE-BODIES.

The ore-bodies are irregular replacements of certain bands lying parallel with the lamination of the schists in a much-faulted portion of the country and in close proximity to a number of amphibolite dykes, with which as on other parts of the Etheridge Mineral Field they have some obscure genetic relationship. They enclose horses of schist, especially in their outer portions, where also the felspars of the included pegmatites have often resisted dissolution; and exceptionally the massive sulphides are sharply marked off from the barren country by a joint, a fissure, a plane of schistosity, or possibly a bedding plane, but in most parts there is a very gradual shading off from what being of payable grade is regarded as copper ore to what containing little or much below, say, 5 per cent. is neglected as country. Thus, on the No. 2 level, over a length of nearly 350 ft., with in one place a width of 100 ft., the copper content of the rock in very few places falls below 1 per cent., yet in this area there are only small and isolated areas rich enough to be stoped.

The porphyry of the great dyke forming the range of hills to the east of the mine has not yet been proved to have had any direct influence on the deposition of copper here; but porphyry dykes are characteristic of other copper areas on the Etheridge Mineral Field; and there is a natural tendency to trace some connection between their intrusion and the uprising or circulating of the cupriferous solutions. On the other hand, their mineral composition places these ore-bodies in the contact metamorphic group, which includes those of Boundary, B.C., of Ducktown, Tennessee, and of Talun, Sweden. By this it is to be understood that the metal-bearing solutions were given off from a deep-seated cooling intrusive mass, and that deposition took place in the overlying contact zone. Pyrrhotite and magnetite alone are criteria of contact metamorphism, and molybdenite and bismuth are even

stronger evidence of the presence of near-by deeper-seated igneous rocks. We may therefore predict that while the schist prevail there will be ore, and there may possibly be an increase in the size of the deposits at the contact with the intrusive.

Details of the structural peculiarities of the exploited ore-bodies will be found under the description of the main shaft workings, but separate notice of the new ore-body is called for because of the hopes recently excited by its discovery in depth.

New Ore-Body.

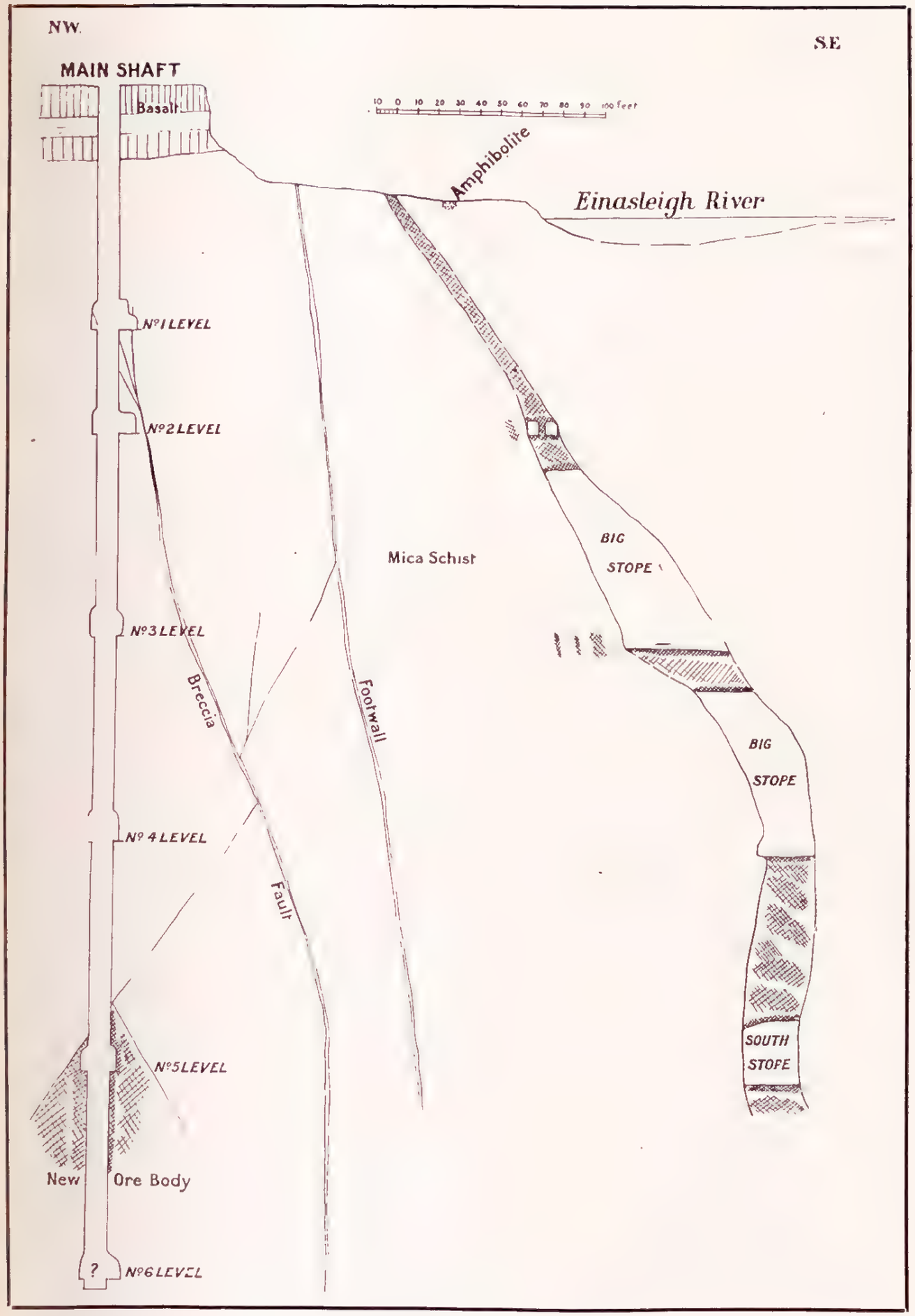
The crop of the river bed ore-body is met over an area 170 ft. in diameter, but much of it is covered by sand, and the whole is usually under water. It lies on the western side of a strong dyke of diorite, which has undergone slight dislocation by an east-west trending composite fault, that also passes across the ore-body.

Bores have been sunk in the river bed to the north and to the south of the ore-body, the former (No. 10) with negative results in a depth of 300 ft. The other (No. 9) cut ore at 15 ft. beneath the surface, and did not pass out till a depth of 115 ft. had been attained. The lode consists of schistose quartzite carrying pyrrhotite, pyrite, and chalcopyrite. The best ore came from between 35 and 40 ft.—1·8 per cent.—but between 60 and 65 ft. there was only a trace of copper. The average for the first 65 ft. was 1 per cent., and from 70 to 90 ft. about ¾ per cent., but from 90 to 115 ft. there was again only a trace of copper. "At 131 ft. there were small veins of copper, and at 190 ft. disseminated pyrite." The total depth of the bore is 223 ft.

A bore (No. 2) on No. 2 level traversed the ore-body for over 100 ft., the average copper content being slightly below 1 per cent.

The main shaft sunk through the body a distance of 69 ft. (from 463 to 532 ft.), where the average is 2·2 per cent. copper. It is believed to have a dip of about 54°, and its width therefrom is calculated to be 41 ft., but this is open to correction. Since my return the body has been intersected on No. 6 level at 20 ft. from the shaft, and the crosscut was still (31st January) in ore at 60 ft. from the shaft, and it has been found to extend 45 ft. along the south-eastern drive; the average tenor in drive and crosscut being 2 per cent.

The ore as elsewhere remarked is distinctly basic, and its proximity to large quantities of siliceous ore is likely to have a great effect in modifying metallurgical treatment at the Einasleigh, besides augmenting the output and prolonging the life of the mine.



EINASLEIGH FREEHOLD COPPER MINE.

Section on Line N.W.-S.E.

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ORES.

The ore now being mined is siliceous, quartz being one of the chief constituents; but it is also pyritic, pyrrhotite being the most plentiful of the sulphides, with lesser amounts of chalcopyrite, the copper-bearing mineral. Blende is fortunately the least plentiful of the common sulphides, and bismuth can be detected only by chemical means. Accompanying the sulphides are small quantities of unaltered biotite, and some scattered masses of pink and white felspar are included in the ore, besides small crystals of garnet. Barite is present in small quantities, and molybdenite can also be detected with a little trouble. The host of the precious metals has not been determined, but it may be any or each of the common sulphides.

It would appear that the ferro-magnesian minerals of the mica schists readily succumbed to the attack of the metal-bearing solutions, and that their replacement with metallic sulphides was comparatively rapid. The amphibolite was more resistent, but, below the new ore-body in the main shaft, amphibolite schist is impregnated with chalcopyrite.

The Einasleigh ores have a general resemblance to several of the largest cupriferous pyrrhotite deposits of the world, most of which, however, have calcite as a gangue mineral. The presence of molybdenite and bismuthinite in those of Boundary and Rossland, B.C., is noteworthy. Garnet is a constituent of the ores of Boundary and Ducktown, Tennessee.

Pyrrhotite,[7] the bronze-coloured magnetic sulphide of iron, is mostly massive, but sometimes assumes a branching habit. It is the predominant metallic mineral of the Einasleigh ore. The possibility of the mineral containing a payable percentage of nickel would seem to have been overlooked, but the required analyses are to be made.[8]

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[7] Pyrrhotite is also a dominant constituent of the Cobar ores, wherein it is associated with magnetite and chalcopyrite. (See Andrews' "Cobar Copper and Gold Field." Mineral Resources No. 17 of the Geological Survey of New South Wales.) It is one of the essential constituents of the ore bodies of Boundary B.C. (where bismuthinite and garnet are among its associates); Ducktown, Tenn., (with chalcopyrite, zoisite, garnet, &c.); Talun, Sweden (with magnetite, &c.) and Rossland, B.C. (with chalcopyrite, molybdenite, &c.)

[8] "Nickel is universally recognised as an associate of pyrrhotite, and in few cases has it proved, when looked for, to be entirely lacking." (See Dickson in Ore Deposits, p. 461). The percentage of nickel varies widely in different pyrrhotites. Those occurring in metamorphosed sedimentary and acidic schistose rocks are notably low in nickel. . . . . and rarely carry more than 0·5 per cent. of nickel."

Chalcopyrite occurs in the schist and also in the felspar and quartz of the accompanying pegmatite, but it is not plentiful in the last-mentioned mineral, and therein is seen only along cracks. In some of the more siliceous ore the chalcopyrite encrusts or cements the non-metallic minerals, and the general effect is that of a dainty inlay. The mineral is sometimes massive, but dendroid vein-like forms are more usual.

Native copper was reported from near the surface, where presumably other oxidised and secondary ores also occurred. The workings now open are all below the zone of oxidation, and, it is believed, below that of secondary enrichment.

Gold has averaged about 4 gr. per ton of ore shipped, but the tenor of the ore lately raised is rather below this.

Silver is present to the extent of slightly under 1 oz. per ton of ore, or, say, 1 oz. to every 6 units of copper.

Sphalerite averages 1½ per cent. according to the assays, but it is not visible to the naked eye. During the year ended October, 1913, there was a falling off from 2·5 to 1 per cent. in the shipments, but this was probably due to the stoping face rising from No. 4 level towards No. 3, for the blende is more likely to increase than to decrease in depth.

Magnetite is present as well-cleaved glossy black granules, and in one place (on the western side of the Big ore-body on No. 5 level) it has been found in dense cryptocrystalline masses, including nests of altered hornblende, specks of chalcopyrite, and a rare flake of molybdenite.

Bismuth, probably as sulphide, is one of the impurities of the ore that have been detected chemically. Fortunately it is present in such a very faint trace that the market value of the smelted copper is not affected by it.

Barite[9] is one of the gangue minerals, but Mr. Brecknell, the company's analyst, informs me that the quantity has fallen from 4 per cent. near the surface to 2 per cent. in the deeper levels. The baryta is indicative of celsian, the barium felspar,

[9] "Baryte is an exceptional gangue, found in abundance in the Shasta county (Cal.) ores, in those of Mount Sicker on Vancouver Island, B.C., and also at Kosaka, Japan, and Mount Lyell, Tasmania. (See Weeds' Copper Mines of the World, p. 33.) The ores and fluxes of Mount Lyell contain up to 12 per cent. barium sulphate, with an average in the payable ore of 2½ per cent. (See Gregory's Mount Lyell Mining Field, p. 93.) Traces of baryta have been detected in both sedimentary and igneous rocks at Cobar, but it does not appear in the published analyses of the copper ore. The ore of Yuspenssky, the most important copper mine in Siberia, contains from 7½ to 11½ per cent. barytes; and at the Tyee Lenora Mine on Vancouver Island, B.C., analysis shows 38 per cent. of the mineral.

being a constituent of the country replaced. A lode of the barite has been located in the schists on the southern outskirts of the Einasleigh township, about a mile to the south-west of the mine; and the fact that chalcopyrite has been found in this deposit is significant as having a possible bearing on the continuation of the Freehold ore-bodies.

Molybdenite[10] specimens have been observed infrequently in the ore raised, but a close examination of my ore samples proves the mineral to be well distributed albeit in minute quantities through much of the ore, embedded in chalcopyrite, in magnetite, and in barytes.

Plagioclase was probably an original constituent of the replaced ore, and, though it may have been in part altered to zoisite, it seems to have been remarkably resistent to the action of the ore-bearing solutions.

Garnet in wine-coloured grains up to ½-in. in diameter is found in some of the ore, more especially in that deficient in quartz.

Quartz occurs in grains in the rich ore, and in the poorer ore, *i.e.*, the less completely replaced country, there is a large proportion, bluish-white and granular, in lumps up to an inch in length.

Biotite flakes, often massed, are plainly residuals of the replaced country rock.

The new ore-body is distinctly more basic than those hitherto exploited. Chalcopyrite in filigree-like veinlets is the copper mineral, but tarnished bronze-coloured and dense pyrrhotite is the dominant constituent, with scattered pebbles of granular quartz in striking proportions. Magnetite is distinguishable as grains up to ½-in. in diameter, the strong cleavage being well developed; and there is a greenish mineral, possibly zoisite (an alteration product of the original felspar). Some specimens have a good deal of white barite, mostly in rounded ¼-in. grains, but it sometimes fills cracks. Exceptionally an included flake of biotite is noticed in the ore. At the surface, where exposed to the weather, the pyrrhotite has partially oxidised to a black earthy-looking material studded with specks of pyrite and slightly veined with chalcopyrite. The order of deposition would appear to have been quartz-pyrrhotite-chalcopyrite.

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[10] Molybdenite also occurs in quantity in some of the copper ores of the Mount Perry district, C.Q.

Chemical Composition.

The mine assay plans show wide divergencies in copper values within the limits of single stopes, but large consignments do not differ greatly in their contents, the average of the ore despatched during the years 1909-1913, as determined by the monthly yields of the Chillagoe smelters, was as follows:—

Gold = 0·0188 oz per ton; Silver = 1·0463 oz. per ton.
Copper = 6·17 %.

The siliceous rejects, from ore raised in 1911-1912, carried:

Gold = 0·0075 oz. per ton; Silver = 0·86 oz. per ton.
Copper = 0·04 %.

Some fairly complete analyses have been made of the ore smelted by Mr. Horsburgh, and from those of 1912-1913 we get the average:

Gold = 0·017 oz. per ton; and Silver, = 0·90 oz. per ton.

Copper	= 5·64 %	
Zinc	= 1·20 %	
Iron	= 20·22 %	(Ferrous oxide = 26·01 %)
Sulphur	= 11·90 %	
Lime	= 3·60 %	
Alumina	= 9·20 %	
Magnesia	= 1·36 %	
Baryta	= 1·51 %	
Silica	= 40·80 %	
	95·43 %	

Included in this there should also be:

Molybdenum = trace; Bismuth = trace; and Tungsten = trace.

The attached graph of production brings out the fact that the silica percentage varies inversely as the copper content; and it also shows the gradual depreciation in copper values with the passing of the years—that is, with the attainment of greater depth from the surface, and the need for increased shipments of ore.

A sample of the new and unexploited body of pyritic ore exposed by blasting in the river-bed assayed:

Copper = 0·78 %
Silica = 19 %.

The same ore-body where pierced by the main shaft shows through a distance of 69 ft. the average:

Copper = 2·2 %
Lime = 10 %
Silica = 32·5 %

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Plate VI.

THE EINASLEIGH MINE AND WORKS.

Viewed from the porphyry dyke across the river. Aplite and amphibolite veined schists of the river bed in the foreground.

Mr. Horsburgh has favoured me with the following analysis representative of 110 tons of ore obtained on No. 6 level since my visit:—

Gold = 0·0083 oz. per ton; and Silver = 0·53 oz. per ton.

Copper	= 2·06 %
Iron	= 28·76 % (Ferrous oxide = 37·0 %)
Lime	= 8·2 %
Alumina	= 7·2 %
Sulphur	= 15·0 %
Silica	= 32·2 %
	93·42 %

The comparative basicity of this ore may have an important bearing on the future of the mine, its lower grade in copper being more than offset by the corresponding lower percentage of silica.

Reserves.

Various estimates of the ore reserves have been made from time to time by different mining engineers. A conservative estimate, made at the end of April, 1913, gave a total of 11,000 tons of ore in sight above No. 4 level; and to this may be added as between Nos. 4 and 5 levels 19,000 tons of probable ore, giving a grand total of 30,000 tons. To arrive at the present (November, 1913) reserves, we must subtract from this the ore mined during the months March to October, 1913, *i.e.*, 14,500 tons, leaving a net total of 15,500 tons. The copper content will be between 5 and 6 per cent.

The state of the mine and the nature of the ore-bodies do not allow of any calculation as to the possible ore here; but, as has been shown above, there are abundant openings for the development of large quantities.

EXPLOITATION.

Natural conditions are not by any means ideal for the winning of the ore. In the first place, all crops are in or near the bed of the river, so, neglecting for the time being the northern deposit which crops in the river-bed below the ordinary level of the water, it was early decided to concentrate all energies on Daintree's ore-bodies; but these also crop below flood-level, and to get the ore without danger of periodical floodings from the rising of the Einasleigh there was no alternative than to place the shaft on the adjacent elevated lava plain—that is, on the western edge of the canon and in the footwall country. The

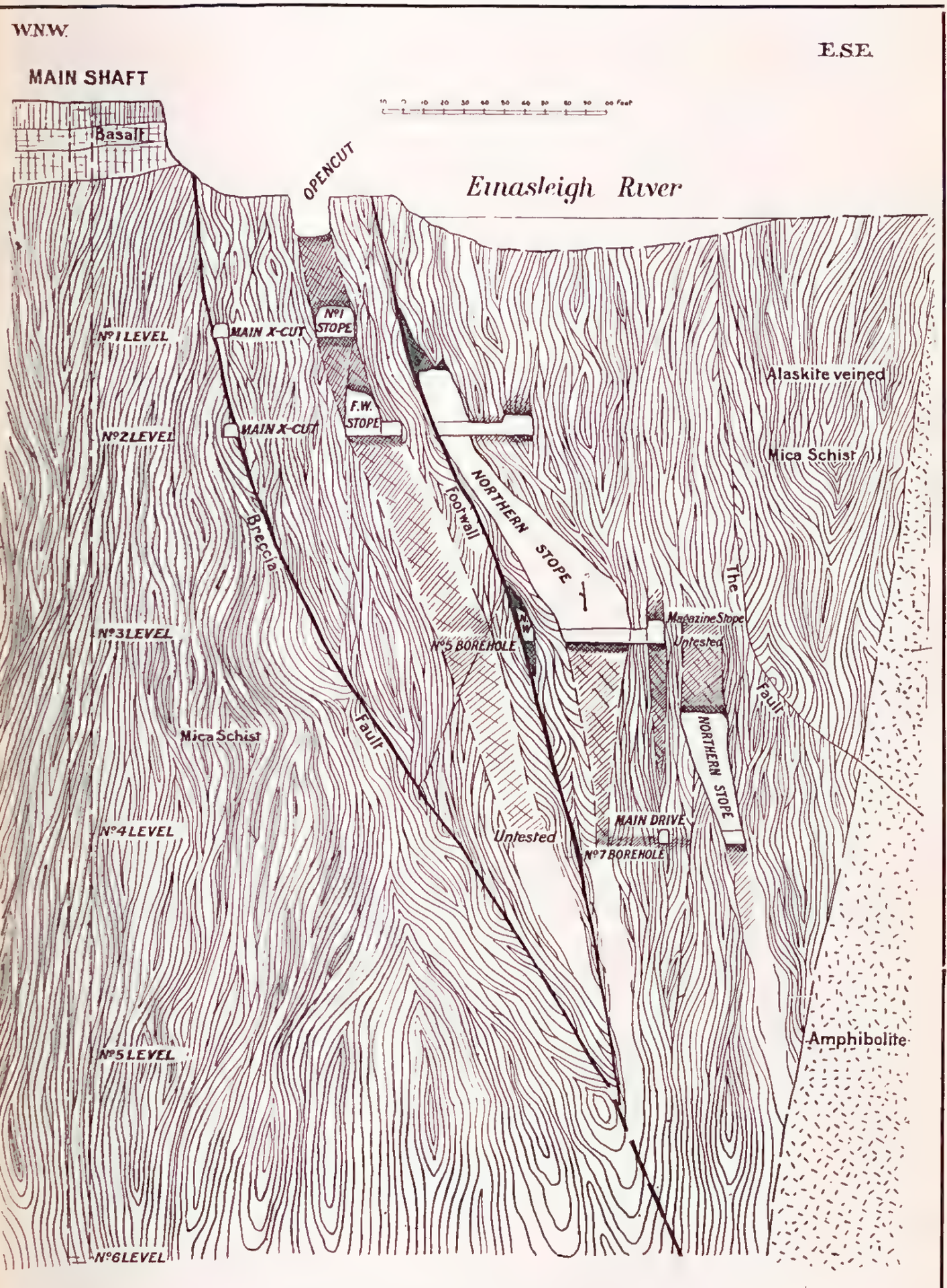
shaft was sunk vertically, and that has necessitated crosscutting an increased distance at each succeeding level, for the reason that the ore-bodies dip east-south-eastwards and away from the shaft. There was, it is true, a roll bringing the workings on No. 5 level directly below those on No. 4, but the dip below is eastwards again. The distance from the shaft to the ore-body at No. 5 level is 320 ft., a handicap not to be ignored in relation to mining costs. The management has seriously considered a proposal to sink a new vertical shaft on the opposite bank of the Copperfield—*i.e.*, at a point towards which the stopes are inclined; but the intersection of the new ore-body in the lower levels has probably shelved the project for all time, and yet it is obvious that to escape the crosscutting a main underlie will ultimately have to be sunk.

The methods of mining in vogue do not call for any lengthy description. At depths of 120, 170, 270, 369, 482, and 582 (?) ft. levels, known respectively as Nos. 1, 2, 3, 4, 5, and 6, have been opened by crosscutting east-north-eastward to south-eastwards and driving along the payably cupriferous portions of the deposits, which have then been attacked generally by overhead stoping.

Surprisingly little timber is needed in the stopes, as the ground stands well, helped out with a few pigsty sets and sand filling. The need for economy in the use of mine timber early made itself felt, and as the stopes are sometimes of large size this method of supporting the depleted stopes had perforce to be resorted to. The sand is obtained from the river bed, hauled up an inclined tramway on to the lava bank, and passed down the South shaft to No. 2 level, along which it is wheeled to the passes as required in the different stopes. The sand is not as cheap a filling as might be imagined, and in the wet season the supply at times is completely cut off.

Trucking is done by wages men, but all mining is effected under the contract system, the management holding that it would be economically impossible to exploit these ore-bodies with day labour. In fact, even as it is, the costs are regarded as alarmingly high.

Ventilation is one of the greatest of the mine manager's worries. It is true that the two shafts are in open communication by way of a drive, but every effort to induce a satisfactory natural circulation has been abortive, and it is needless to disguise the fact that artificial ventilation will soon become imperative.



Einasleigh Freehold Copper Mine.

Section on Line W.N.W.-E.S.E.

The normal complement of underground employees is 65, and of surface hands 25. A production of 1½ tons [11] per underground employee per day is expected, but towards the end of the year the output fell to less than 1 ton, which means that exploitation was then unremunerative. With a monthly output of 3,000 tons mining costs, exclusive of development, have been about 12s. 6d., but with restricted output owing to tardy development they rise to 18s. per ton of ore.

It is believed that in supplying 100 tons of ore each day at the insistent demand of the Chillagoe smelters, the management overtaxed the economic possibilities of the ore-bodies, which after all are not of vast size; but it is candidly admitted that development has always been allowed to lag, and that this was the chief factor in shrinking up the output during the last few months of 1913, accentuated it may be by the partial failure of the Big body on No. 5 level. The approaching exhaustion of the stopes above No. 4 and the losses incurred through too great reliance on the constancy of the Big ore-body below No. 4 level have brought home to the management the need for instituting a vigorous policy of expansion of the deeper workings. Consequently the ore-body on No. 5 is being driven on; on No. 6 level two crosscuts are being thrown out, one to the old and one to the new ore-body; and the main shaft is to be sunk another 100 ft.

Surface Workings.

Of Daintree's original outcrop and shallow workings little is now visible because of encroachments by the mullock dumped from the main shaft. Dr. Jack, who visited the mine in 1898, wrote [12] that "The cap of a lode is seen beneath the bank, and is traceable for 180 ft. to the N. 15° W., when it disappears under the basalt. I took its width to be 40 ft., and should roughly estimate that the ore visible (mainly carbonate) would go at least 10 or 12 per cent. of copper." He does not seem to have been able to locate Daintree's workings, wherein the lode was proved to have a width of 23 ft. at 30 ft. depth. Ferruginous and cupriferous crops there are between the basalt and the river's edge to the east of both the main and the south shaft, and the schists of the latter are also cupriferous in the old southernmost drive on No. 2 level; but it is fairly certain that Daintree's ore-body has not been tapped by the modern underground workings.

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[11] At Mount Morgan, during 1913, the ore handled per underground employee per shift was 1·32 tons, so that we may look upon the above result as more than satisfactory.

[12] *Op. cit.* G.S.Q. Publication No. 134, p. 20.

Copper ore was raised from three other shallow shafts, respectively 2, 3, and 5 chains from the main shaft and to the north of Daintree's open cut, but records of developments therein are wanting, and no underground connections have been made with the new workings.

Across the river a-quarter of a mile to the north of the main shaft a cupriferous and ferruginous crop of schist has been discovered between two dykes of aplite. It is small, and does not offer any promise of great riches, and after driving 6 ft. on it the intention to drive an adit was set aside.

Still another small crop was located further up the slope, about 5 chains to the east-south-east of that last-mentioned. An adit opened in it, continued about 50 ft. in silicified gossany altered schist with traces of copper until it impinged on the western wall of the great porphyry dyke that forms the upper part of the ridge.

Main Shaft.

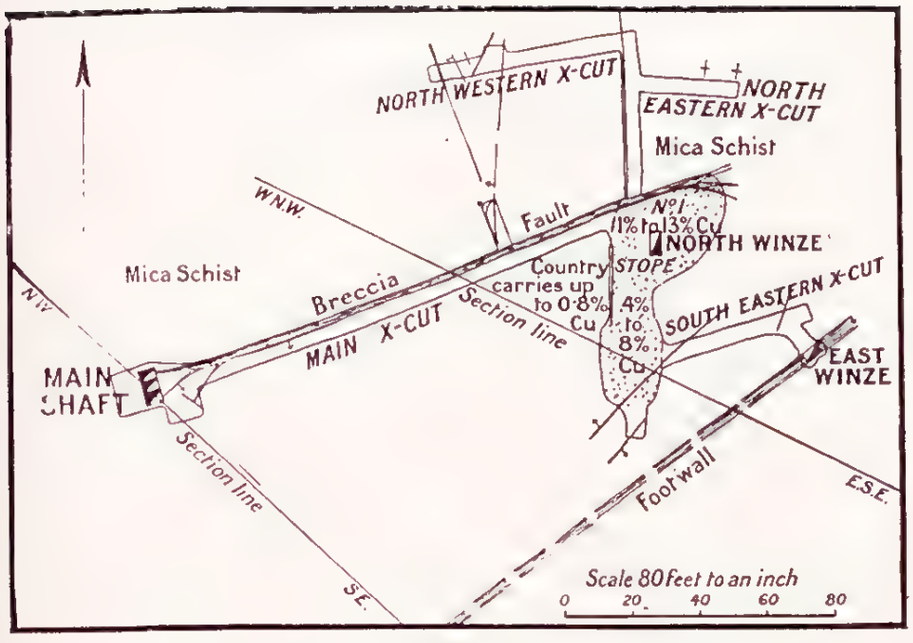
The Einasleigh main shaft is surrounded by a most imposing array of buildings, among which are the engine and boiler houses, smithy and engineers' shop, and the edifices sheltering the extensive but discarded treatment plant erected by the New Einasleigh Company in 1910.

The shaft, which is divided into three compartments, is spanned by a round timber head frame with pulley sheaves about 60 ft. above the ground. In winding, the full trucks are raised to a staging 30 ft. above the surface, whence they are run out and, without any picking or sorting, emptied into the railway hoppers.

All plans at the mine having been placed at my disposal, the most recent, by Mr. G. A. Douglas, were chosen as a basis for my work. From old plans by Messrs. W. W. Webster, W. W. P. Wellman, and C. W. Ross many assay records were derived; and use was also made of Mr. Douglas's assay plans on which the mine was valued and purchased by the Chillagoe Company. On none of these plans had the geological features been delineated, and such being the case the wonder is that even a moderate measure of success has followed the developmental work done.

No. 1 Level.

The crosscut thrown out towards the east-north-east was made to closely follow a strongly ferruginous fault formation of kaolinised brecciated country, carrying in some places nearly



EINASLEIGH FREEHOLD COPPER MINE.

No. 1 Level (120ft. depth).

1 per cent. of copper.[13] This formation does not extend to the west of the shaft, and it is doubtful if it will continue much beyond the end of the adit, where it has split up into several branches.

Though the ore-body sought was missed, another was struck at 140 ft. from the shaft. This is known as *No. 1 ore-body*. It has a width of 30 ft. along the fault, and it has been followed out southwards for a distance of 70 ft., showing a gradual contraction. The ore averaged nearly 8 per cent. copper, and it was stoped up 10 to 15 ft. above the level, where work ceased because of the possible proximity of the river-bed and the consequent danger of flooding. Below the level no stoping has been done on the northern lobe, but the Footwall stope on No. 2 level is in the southern lobe; and the low-grade ore of No. 5 bore on No. 3 level may well belong to this ore-body.

The causation of No. 1 ore-body has not been definitely ascertained, but it seems safe to assume that the fault breccia served as a conduit for the metalliferous solutions which passed out into and impregnated with sulphides a favourable band of country abutting against the fault.

Exploration.

On the northern side of the breccia formation there is no trace of No. 1 ore-body; but a small ferruginous formation has been driven on and crosscuts have exposed numerous open joint planes in the mica schist, with only small bunches of cupriferous gossan near them. In the north-western crosscut off this drive there are several joints whence flow strongly chalybeate waters, pointing to the existence nearby of an oxidising pyritic body, possibly Daintree's, which further search hereabouts might reveal.

The strong fault plane, known in the lower levels as the Footwall, reached No. 1 level, but, notwithstanding that only 20 ft. below the level an average width of 14 ft. of ore has been stoped along its southern side, there is here only 3 or 4 ft. of formation, and this peters out upwards.

NO. 2 LEVEL.

On No. 2 level to the south of No. 1 ore-body there are five stopes, two of them on the Footwall, and others on joints intersecting what is known as the Composite Fault.

[13] Mr. Smith informs me that copper can be detected on assay in almost any of the country rock on this level.

The breccia formation of No. 1 level was met and followed for 240 ft. from the main shaft by the main crosscut, but the No. 1 ore-body was not thereby exposed.

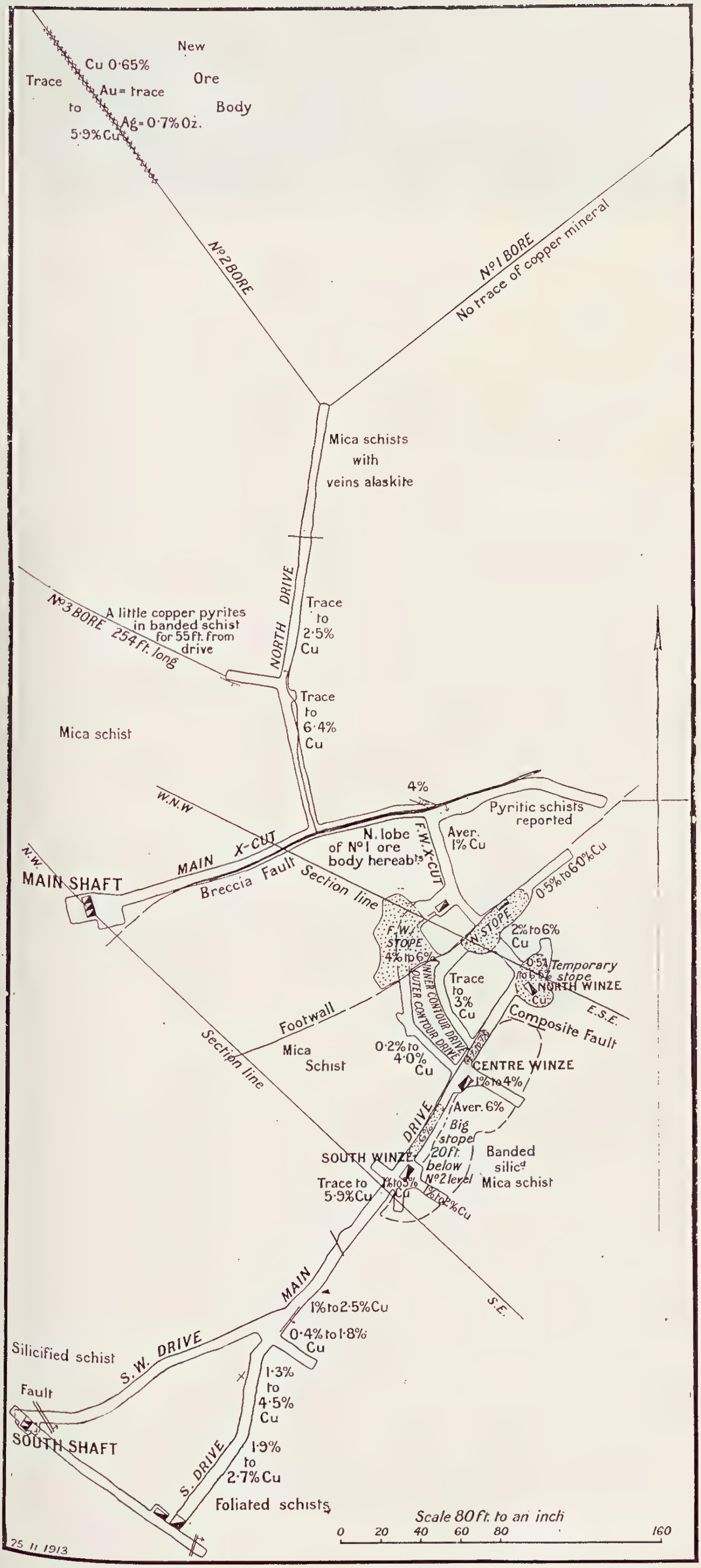
In branching southwards off the crosscut near where it is thought the northern lobe of No. 1 ore-body will yet be located, the Footwall (here a 6-in. iron-stained serpentinous crush formation) was intersected. On the far side of this is the *Northern ore-body* with copper values averaging 5½ per cent. This has been stoped over a length of 40 ft. and a width of 14 ft. from just below No. 1 level downwards to No. 3, with highly satisfactory results.

Nearly 20 ft. to the south-west is the *Footwall ore-body*, triangular in plan, with its base of 30 ft. along the Footwall, and its height of 40 ft. out to the north-west, *i.e.*, on the near side. This has been stoped up 35 ft., yielding the Chillagoe Company 2,000 tons of ore. The manager considers the backs, where there is 10 per cent. ore showing, the best face in the mine. This body is perhaps the southern lobe of that stoped on No. 1 level. Its downward extension has not yet been proved, though on the next level low-grade ore was located by No. 5 bore, at a place where this body should be looked for.

The Footwall crosscut, 20 ft. beyond the Northern stope, again entered ore, which was being stoped over a length of 30 ft. and a width of 15 ft. during my visit, but the ore is really below the payable grade. (See the *North Winze.*)

The main drive to the south-west of this stope is in cupriferous ground over its whole length, but the value of the *Big ore-body*, being worked up from No. 3 level, fails to 2½ or 3 per cent. a few feet below No. 2 level. That is, except for two small areas, one between the Northern and Central winzes, and the other between the Central and Southern winzes, the latter of which has been stoped up for 20 ft., on an average of 3 ft. 6 in. of ore containing 6 per cent. copper.

The Big stope below No. 2 level has a length of 120 ft., and a width of up to 40 ft., with copper contents as high as 10 per cent. It has yielded the Chillagoe Company 16,000 tons of ore and the New Einasleigh Company's production was still greater, the grand total from between Nos. 2 and 3 levels being estimated at 40,000 tons. The body in places where the silicified schists are well laminated has a distinct hanging-wall, but the usual rule is for the ore to gradually shade off into low-grade cupriferous country. At the northern end it abuts against the Composite Fault, here rather indistinct.



EINASLEIGH FREEHOLD COPPER MINE.

No. 2 Level (170½ft. depth).

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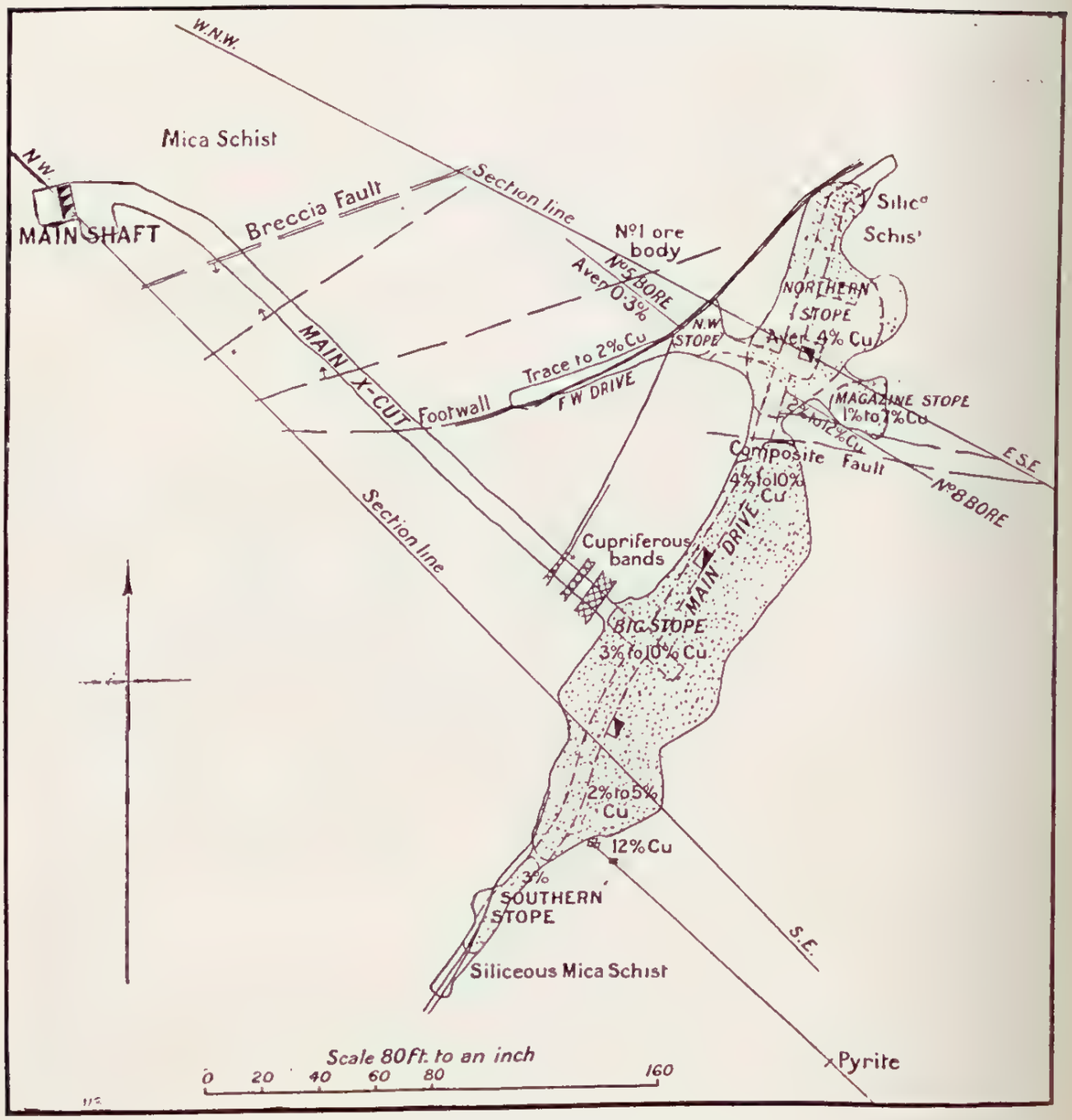


EINASLEIGH FREEHOLD COPPER MINE.

No. 3 Level (269½ft. depth).

Exploration.

A northern drive runs out 230 ft. from the main crosscut in mica schists interlaminated with quartz-felspar rock of the nature of pegmatite; and copper values, running from a trace to 6½ per cent., were found between the 40 ft. and 120 ft. marks. From the middle of the cupriferous area a crosscut was put in a short distance to the west, but both it and a long borehole from the end failed to locate any copper ore. The strong seepages, from which ferruginous stalactites are being precipitated, are nevertheless indicative of an ore-body in the vicinity, and some further exploratory work is desirable here.

Two other boreholes were run out from the end of the drive: one to the north-east, and one to the north-west. The latter at a point 360 ft. north of the main shaft entered cupriferous country and continued therein over 100 ft. The assays recorded vary from a trace to 5·9 per cent. copper, the average of the cores and cuttings being:

Gold = trace; and Silver = 0·7 oz. per ton.
Copper = 0·8 %.

This, as explained in another place, is believed to be one and the same as the *New ore-body* of Nos. 5 and 6 levels and of the river bed to the north of the main shaft.

NO. 3 LEVEL.

On No. 3 level there are also five stopes, but they are almost continuous, being in one great cupriferous area or formation. This takes off from the footwall, from which it has been followed out to the south-south-west for a distance of 320 ft., its greatest width being 80 ft.

The *North-western stope*, which is about 12 ft. in diameter, rests directly on the footwall, and it extends but 12 ft. above the level. The ore is very siliceous but runs about 6 per cent. copper. The continuation of this ore-body is to be looked for to the south-south-west along the fault that meets the main crosscut 220 ft. from the shaft.

The *Northern stope* is 85 ft. long and 15 to 45 ft. wide. This is now timbered up and, outside of the roads, inaccessible; but it is understood that values here were lower than in the other stopes.

The *Magazine stope* may be regarded as a branch of the Northern, lying like it to the north of the Composite Fault. It is but 10 ft. high and 20 ft. in diameter.

The *Big stope* is 160 ft. long and has an average width of 35 ft. As already mentioned it reaches upwards to within 20 ft. of No. 2 level and downwards to No. 4. From this has come the major part of the mine's output of ore, averaging about 6 per cent. copper. During my visit stoping was still in progress 10 to 25 ft. below No. 3 level.

The *Southern stope*, just beyond the end of the Big stope, is 40 ft. long, 5 to 10 ft. wide, and 20 ft. high. It has yielded 600 tons of ore, but in the backs copper is present to the amount of only 3 per cent.

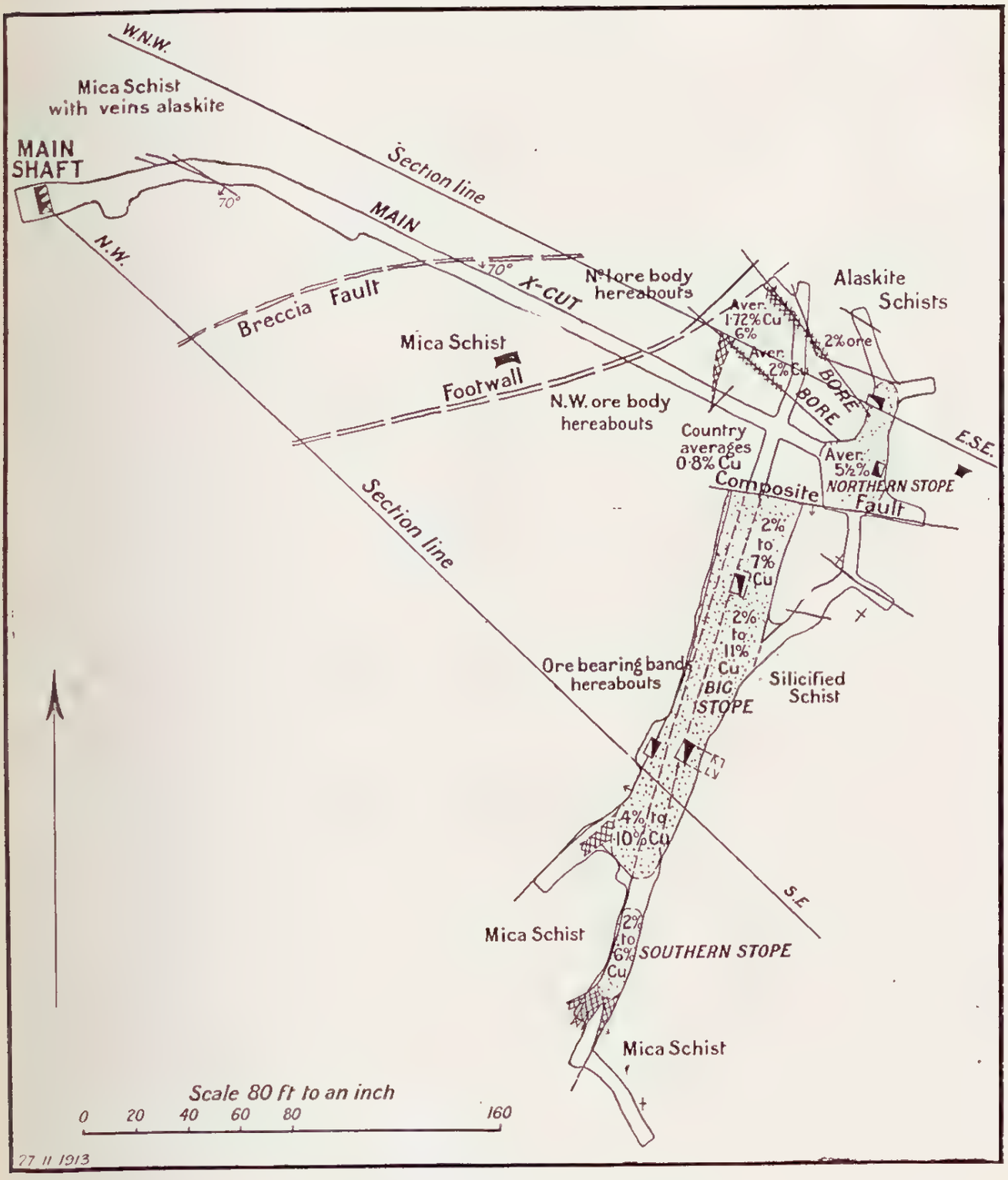
Exploration.

Exploratory work is desirable at several places on this level. Thus the possibility of an ore-body lying along the footwall to the west of the main crosscut should be investigated by driving. Then, again, low-grade ore, reasonably believed to be part of the footwall ore-body of No. 2 level, has already been found in No. 5 bore, and the search should be renewed, preferably by prolonging the crosscut and driving off it, as there is a fair chance of richer ore occurring on either side of the bore. The capabilities of the cupriferous bands pierced by the crosscut to the west of the Big stope should also be determined by driving on them or perhaps better by putting out short boreholes from the Big and the Southern stopes. To locate the upward continuation of the Northern ore-body of No. 4 level, the Composite Fault should be followed to the eastwards from the Big or the Magazine stope. Lastly, the formation at the southern end of the main drive is of such a nature that continued driving might well result in the discovery of new ore-bodies.

NO. 4 LEVEL.

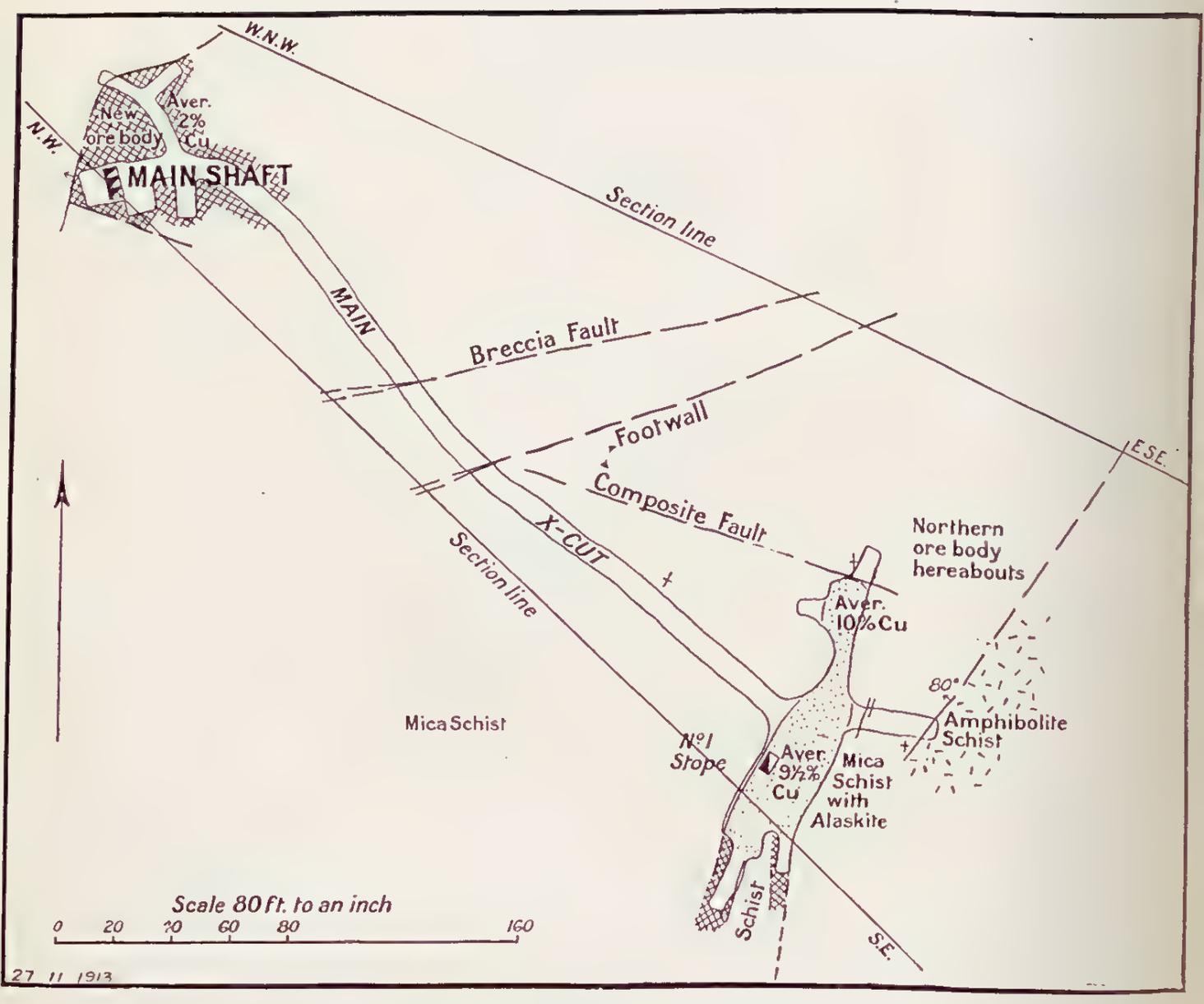
Exploitation has not been on quite such a large scale on No. 4 level as above. The ore-bodies on the footwall, where cut by the main crosscut, have fallen below the payable limit; and this may be due to the Composite Fault having become the chief channel of origin of the mineralising solutions in this part of the mine, or it may be due to some difference in the original mineral constitution of the country. It is not likely that there has been any great permanent falling off in the size or value of the lodes at such a shallow depth.

The *Big stope*, the only one of those reaching the upper levels, is here 150 ft. long and on the average 25 ft. wide; and it has been proved to continue to No. 5 level, with a strong clean footwall but without defined hanging-wall. The ore contained 3 to 10 per cent. copper.



EINASLEIGH FREEHOLD COPPER MINE.

No. 4 Level (368½ft. depth).



EINASLEIGH FREEHOLD COPPER MINE.

No. 5 Level (482 ft depth).

The *Southern stope*, beyond this, is about 35 ft. long, 8 ft. wide, and 20 ft. high. The ore broken down contained not more than 4 per cent. copper; and the body is probably the Southern of No. 3 level.

The *Northern stope* is another on the opposite side of the Composite Fault, and to the east of the Big stope. At the fault it is 40 ft. wide, but it gradually tapers out within 50 ft. to the north. The body has been stoped up to within 45 ft. of No. 3 level, but has not yet been sought for above, though the tenor of the ore is distinctly above the average.

Exploration.

A good deal of prospecting by driving and by boring has been undertaken in search of the *Northern* and *North-western ore-bodies* of No. 3 level; but, unfortunately, the results of boring have not been confirmed by crosscutting. It is suggested that this may be due to a clerical error of the drillers having caused the transposition on the plans of the records of Nos. 6 and 7 bores. If the correction be allowed the rich ore that has been unsuccessfully sought in the Borehole drive should be found between the end of that drive and the main crosscut.

There is reason to believe that the whole of the country between the Northern stope and the footwall carries a little copper, and the possibility of recovering this at some time in the, perhaps, distant future should not be forgotten. In a well-designed scheme of exploration the footwall to the west of the crosscut should not be neglected as a promising means of guidance to new ore-bodies. Lastly, although the Big formation seems to split up outside of the southern stope, there is still some ore showing, and this should be followed until it cuts out or makes again.

NO. 5 LEVEL.

At No. 5 level the *Big ore-body* is 300 ft. distant from the shaft and it has undergone a somewhat serious contraction in size, but with decreased dimensions there has been a distinct improvement in the quality of the ore, the average copper content being 9½ per cent., and where first cut it ran 14½ per cent. This, be it noted, is contrary to the usual experience of the mine managers in this mine, where the widest faces have been the richest. From the Composite Fault (or one of its branches) on the north the body, at the time of my visit, had been opened up for 120 ft. to the southwards and its greatest width was 25 ft., the mean being much less. At about 40 ft. from the main cross-

cut, a tongue of schist causes a bifurcation, one arm about 5 ft. wide continuing to the south, the other, probably 10 ft. wide, trending south-south-west.[14]

Amphibolite schist is showing in the end of the main crosscut, and this, as elsewhere demonstrated, is probably the prolongation of the dyke forming the footwall at the crop.

The *New ore-body* at the shaft is bounded on this level by a strong head on the west and north, but on the south and east there are no defined limits, the dense sulphides graduating out through pyritic country into barren schists. As proved by the main crosscut and north drive the ore-body has a diameter of about 75 ft. It contains garnet and is much more basic than the eastern ore-bodies, but it is very low in copper, the average being only 2 per cent. The main shaft, in which it was encountered first at a point 19 ft. above, passed out of the ore 50 ft. below the level, but the ore-body has been again located on No. 6 level since my departure from Einasleigh. It had also been previously tapped by a bore on No. 2 level and its crop has been found in the bed of the river, 600 ft. to the north of the main shaft. Its dip is thus 1 in 1½ to the south-south-west, whereas the eastern ore-bodies dip 2 in 1 to the east-south-east.

Exploration.

There is a large area to be proved around the Big ore-body, but little to guide us in prospecting. The footwall was intersected by the crosscut, 140 ft. back from the ore-body, and, though it gave forth a good flow of water, there is no sign of copper ore on it at that point. The branch of the Composite Fault at the northern end of the stope is an open crack corresponding to that on No. 4 level, but as the fault is compound in structure, other branches may be met if the drive be continued some feet. It probably intersects the Footwall at no great distance to the north-east of the crosscut; and, as there may be other ore-bodies along both of them, it would seem to be proper to begin driving along the Footwall and also along the Composite Fault to the west as well as to the east. We may confidently look for the *Northern ore-body* of the latter level within 50 ft., and possibly within 20 ft. to the east of the end of the northern drive, and search for this should be undertaken without delay.

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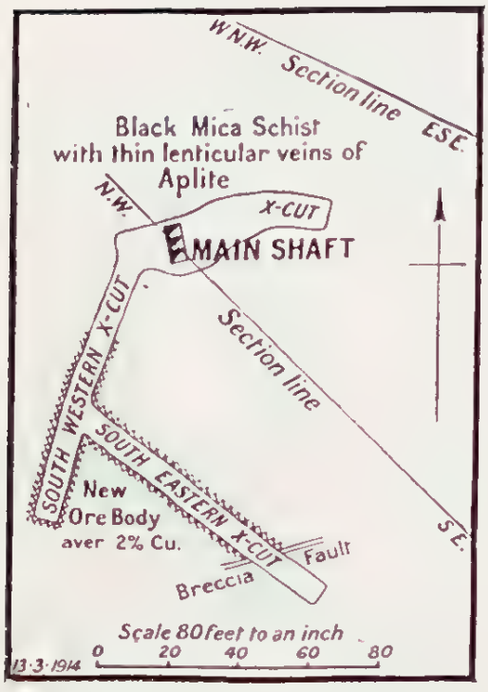
[14] The latter has now, at the end of February, 1914, been driven on for 100 ft. from the shaft—with a gradual thinning out to 3 ft. 6 in. in the face, where the copper amounts to but 1 per cent. The former arm has been intersected by a crosscut from the end of this drive, and, as it has a width of 7 ft. and carries 3·8 per cent. copper, it is intended to drive further southwards along it.



EINASLEIGH FREEHOLD COPPER MINE.

No. 6 Level (582ft. depth ?).

NO. 6 LEVEL.

On No. 6 level a start has been made to crosscut towards the eastern ore-bodies, and since my return to Brisbane some important developmental work has been carried out on the *New ore-body*. From Press notices it is gathered that, in the south-western crosscut, the ore began to appear at 30 ft. from the shaft and continued to the end, a total distance of 60 ft. Values fell from about 2·9 per cent. in the first part to 1½ per cent. in the end, the average of all samples being 2 per cent. copper. The south-eastern drive off the crosscut is in the middle of the deposit. For the first 30 ft. the average content is 2 per cent., then there is 17 ft. averaging 1·8 per cent., and as the value of the remainder is not mentioned it is presumably lower still.[15]

Even though the ore be of a basic nature its poverty in copper, gold, and silver is likely to prevent its profitable exploitation, while subject to the ordinary charges of mining and treatment; but, as a flux for the more siliceous ore, it appears to have an intrinsic value.

OUTPUT.

The earliest recorded statement of output is that for the year 1901, when 1,009 tons of ore was smelted locally and yielded 101·616 tons of copper (*i.e.*, 10 per cent.) with 1,330 oz. silver (or 1·3 oz. per ton of ore).

In 1907, 12 6/20 tons of 14 per cent. ore was sent away; and in 1908, 19 12/20 tons of 4½ per cent. ore was despatched from the mine.

For the subsequent years the reader is referred to the attached figure, whereon is graphically condensed a mass of statistics placed at my disposal by Mr. J. Horsburgh. On this may be observed the extreme fluctuations in the monthly shipments of ore, and the slight progressive annual increases; but it will be noticed that the annual yield of copper remains stationary, owing to the fact that there is a gradual fall in the metal content of the ore.

During 1909, the average monthly output was 1,360 tons; in 1910 it rose to 1,680 tons, but fell again in the following year to 1,200 tons. In 1912, there was a sudden jump to 2,000 tons and even this was bettered in 1913 with 2,200 tons per month.

[15] Mr. Horsburgh, writing under date 13th March, 1914, informs me that the eastern crosscut is in 40 ft. from the shaft, and the southern crosscut 90 ft. The latter, in intersecting the new ore body, has proved a width of 45 ft. and the same body has been driven on a distance of 75 ft. The average copper contents of the ore body is 2 per cent. " and the ore is distinctly more basic than the main body previously worked." The ore body is bounded on the south-east by a fissure, most likely the Breccia Fault.

During the period beginning April, 1909, and ending in October, 1913, a grand total of 94,015 tons was treated and the yield of copper was 5,734 tons, containing 1,746½ oz. gold and 97,065½ oz. silver. Included in this is 103½ tons of ore, carrying 2·7 per cent. copper, got while sinking the main shaft between Nos. 4 and 6 levels. In October and November, 1911, and March, 1912, there was also raised 3,690½ tons of siliceous ore containing: 139 tons of copper, 27½ oz. of gold, and 3,199 oz. of silver.

Over short periods the mine has yielded smelting ore at the rate of 100 tons a day, but for various reasons it has become impracticable lately to even distantly approach this figure.

TREATMENT.

The ore shipped has been given practically no dressing at the mine. It is pyritic and siliceous, containing, say—

Sulphur = 12 %,
Silica = 41%;

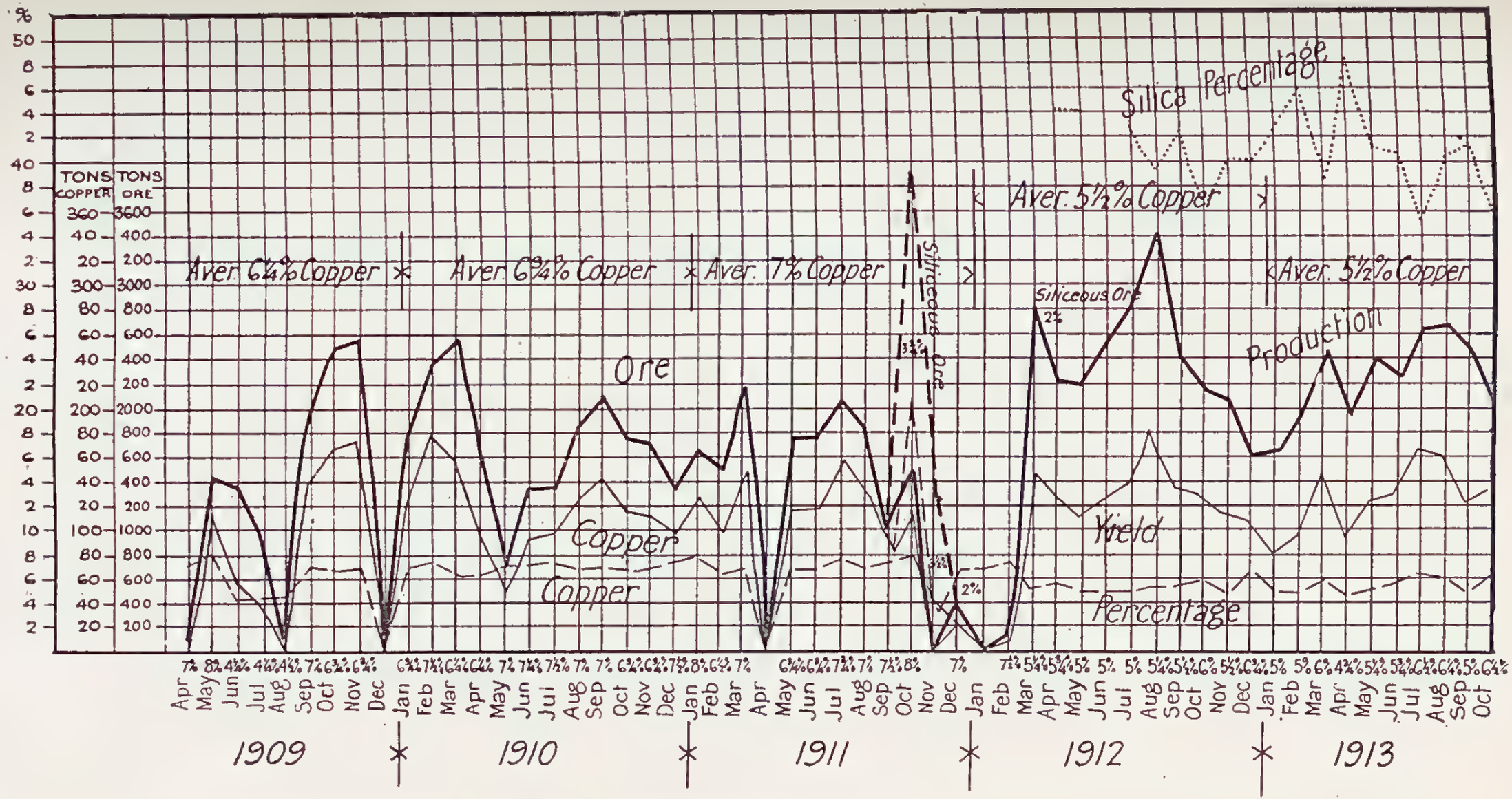
and the average grade of the ore reaching Chillagoe is represented by the following figures:—

Gold=9 gr. per ton; and Silver=1 oz. per ton
Copper=6·17 %.

The new ore-body has a distinctly more basic character than the above and is regarded as self fluxing; but, at the same time, it is much lower than the old in copper, the average being probably below 2 per cent. Its value as a flux for the siliceous ore has been recognised, and it is expected to be utilised either with or without mechanical concentration in improving the ore charge for the smelter. For consignment to Chillagoe, however, it is considered that a minimum of 4 per cent. copper is required. It is thus evident that, unless the exploratory work now in progress shows a great increase in the metal percentage, local treatment will have to be relied on.

The long haulage to port has always militated against the profitable running of the mine and even when the Chillagoe railway reached Alma-den, the 100 miles of cartage was felt to be too costly to allow of the medium-grade ore being despatched. A water jacket blast furnace was therefore erected and blown in during 1901, but the campaign was a short one, and the furnace was permanently closed down on two counts—the siliceous nature of the ore and the high cost of fuel.

The advent of oil flotation processes raised fresh hopes and a new company installed an Elmore unit, with other extensive plant, which seems to have been a complete failure.



GRAPH OF PRODUCTION, 1909-1913.

EINASLEIGH FREEHOLD COPPER MINE.

(Compiled from figures supplied by the general manager.)

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Plate VII.

THE MAIN SHAFT AND TREATMENT WORKS,

With Elmore building on the left. In the distance Red Rock, a part of the great porphyry dyke across the river from the mine.

Upon the opening of the Etheridge railway negotiations were entered into for the carriage of the ore to the Chillagoe smelters, and, as the mine has since passed into the Chillagoe Company's hands, the same arrangement is still in force. It might be thought an uneconomical procedure to rail the ore 120 miles, but the company has probably regard to the small reserves and is unwilling, if able, to incur the great expense of erecting smelters at Einasleigh, especially as the profits from the carriage of the ore go into its coffers in the end. Incidentally, it may be mentioned, however, that there is a direct loss to the mine in the carriage of the ore as against the corresponding coke and copper, and this may amount to many thousands of pounds sterling per annum when the mine is in full swing.

The matter of preliminary concentration by the Mineral Separation process is engaging the attention of the company's metallurgist, in view of the splendid results attained at the Havelock mill, Forsayth.

Meanwhile, with the primary object of effecting a saving in freight, the possibilities of hand-picking such ore as that now being shipped have been systematically investigated by Mr. Horsburgh, who set himself the task of demonstrating practically the feasibility of appreciably reducing, by mechanical means, the proportion of low-grade schist unavoidably mixed with the ore raised. He took, at random, a truck load—nearly 6 tons—of ore as received at the Chillagoe smelters and passed it over a travelling belt, whereby he was enabled to throw out the biggest lumps of substantially barren country rock (nearly 7 per cent. of the total). He then had the remainder crushed to 4-in. size, and divided it also on the belt into fine and coarse; and from each of these products the apparently barren rock was picked, leaving fine and coarse clean ore amounting to nearly 80 per cent. of the total. The net result was that 5·75 tons of run of mine ore was reduced to 4·5 tons of firsts, 20 per cent. of poor country rock being discarded. Concurrently, the copper content was raised from 5·6 to 6·6 per cent., the ferrous oxide from 26 to 30 per cent., and the sulphur from 11½ to 14 per cent., while the silica fell from 41 to 36 per cent., lime and alumina remaining unaltered, respectively 4 per cent. and 11½ per cent. Thus, in place of a very siliceous ore requiring lime and iron fluxes, the metallurgist has to hand a self-fluxing mixture.

31st March, 1914.

By Authority: Anthony James Cumming, Government Printer, Brisbane.

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VICTORIA.

Queensland.

DEPARTMENT OF MINES.

Queensland Geological Survey.

(B. Dunstan, Government Geologist.)

PUBLICATION No. 247.

Petroleum and Natural Gas Prospects at Roma.

Reports on the Occurrence of Gas in the Roma Bores and on the Prospects for Petroleum,

BY

W. E. CAMERON, B.A. (Cantab.),
ASSISTANT GOVERNMENT GEOLOGIST.

ALSO

Reports and Correspondence on Prospects for Petroleum and Proposals for Development,

BY

SIR BOVERTON REDWOOD, Bart.,
SIR THOMAS ROBINSON, K.C.M.G.,
DR. A. C. VEATCH,
WM. HOPE HENDERSON, M.I.M.M.,
P. CHARTERIS A. STEWART,
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LIONEL C. BALL, B.A., B.E. (Syd.).

EDITED BY W. E. CAMERON.

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INTRODUCTORY NOTE.

By B. Dunstan, Government Geologist.

The whole of the Departmental geological work connected with oil-prospecting operations has been in the hands of Mr. Cameron, who has written a number of short reports on the subject of natural gas occurrences and on the probability of finding petroleum. In view of pending oil-prospecting operations on an extensive scale in the Roma district it is considered advisable to publish all the reports and notes issued since 1904, the year when inflammable gas was discovered in a deep bore in this locality.

It might be of some interest to state that the horizon of the gas at Roma is below the known coal seams outcropping to the north of Roma, which are probably in strata belonging to the Walloon Series. The relation of what might be termed the gas belt to the artesian water belt is well defined, the horizon of the latter being the Walloon Series in and about the coal seams, while the gas is in strata below this position—although probably in the same series and not in the Permo-Carboniferous. The three zones are, in descending order—(1) the Marine Beds of the Rolling Downs (Cretaceous); (2) the Walloon coal seams and artesian water beds (Jurassic); and (3) the gas belt (Jurassic). (*See* Fig. X.).

It has often been contended that with so many deep water bores indications should have been noticed if oil existed in the large artesian basin of Western Queensland; but, as the gas zone in the Roma bore is far below the water zone, nearly all the bores for water have been too shallow to indicate the presence of oil even if it existed. The undisturbed conditions of the Cretaceous and Jurassic strata in the artesian area must also be a factor for consideration, as the impermeability of the rocks, in preventing the upward leakage of water under pressure, would also prevent indications of oil appearing above the horizon at which this water occurs.

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PETROLEUM AND NATURAL GAS PROSPECTS AT ROMA.

I.—PREFATORY AND HISTORICAL.

By W. E. Cameron, Assistant Government Geologist.

The striking of hydrocarbon gases in large volumes in two of the Roma bores, first in 1900 and again in 1908, has been a subject of increasing interest in Queensland during the last few years owing to its presumed significance as an indication of the presence of oil, although opinions have been somewhat sharply divided on this point, even amongst geologists who have given some attention to such subjects. On the one hand, the significance of this occurrence at Roma has been regarded with pronounced scepticism, and on the other hand with a good deal of hope and even of confidence.

The reason for this divergence of opinion amongst geologists is to be found in the fact that, up to the present, no very definite and readily applicable criteria have been discovered in the constitution of natural hydrocarbon gases, by which it can be determined whether such gases have been given off from oil, or are merely accumulations of methane and other hydrocarbons given off from coal seams with no accompaniment of oil. The varying opinions therefore held by geologists have been based on somewhat indefinite accompanying phenomena, interpreted empirically and differently, according to the varying experience or reading of each exponent. They are to a great extent a confession of our present lack of knowledge of the genesis of hydrocarbons by natural processes.

The most definite opinion adverse to the conclusion that the Roma gas was given off from oil is contained in remarks made by Mr. J. E. Carne, Assistant Government Geologist for New South Wales, in Bulletin No. 1 of the Territory of Papua, published by the Department of External Affairs of the Federal Government in 1913. These remarks are quoted in full in No. XI. of this issue. Mr. Carne gives five reasons for considering that the gas at Roma was derived from coaly beds and that the indications were against the possibility of oil being struck.

This adverse opinion is again reflected in a report published in 1914 [1] by the Second Interstate Conference on Artesian Waters, on which were the Government Geologists of several of the Australian States. This pronouncement must be taken as embodying the opinion of the majority of the geologists on that conference.

In paragraph 7 of that report appear the following words:—"It is probable that the bore (the Roma bore.—W.E.C.) had tapped an accumulation of methane derived from the coal seams which are known to occur there."

The only coal seams known absolutely to occur below Roma are one or two thin seams met with at about 750 ft., and some half dozen seams, also probably thin, at about 2,000 ft. in the bores. The gas belt lies 1,500 ft. below the lowest of these seams. Presumably it is not contended that the gas was given off from any of these seams and carried down through 1,500 ft. of strata, but from lower seams presumed to exist. The occurrence of such large volumes of gas with the characteristic paraffin-like odour observed in the Roma bores, as an ascertainable product of coal seams, without the total destructive distillation of such seams, would seem to have been, to say the least of it, very infrequently observed or recorded. Any action powerful enough to have produced such large volumes of gaseous hydrocarbons from carbonaceous material, if they were derived from carbonaceous material, may reasonably be expected—in the present state of our knowledge of the formation of natural hydrocarbons—as being likely to have been sufficiently intense to have also caused the collateral effect of a production of liquid hydrocarbons, even if such have not subsequently been concentrated into commercially valuable deposits.

As long ago as November, 1904, and again in September, 1911, the writer, in reports to the Under Secretary for Mines, advanced the opinion that the probabilities were in favour of the gas struck at Roma having been given off from oil, this opinion being based on the very large quantities of gas evolved and its peculiar paraffin-like odour.

In July, 1912, the Mines Department was instructed by the Premier (the Hon. Digby F. Denham) to prosecute a thorough investigation into the possibilities for oil at Roma, it being the Government's intention to themselves prospect the district. Being aware of the adverse though at that time not definitely expressed opinions of many of Australia's leading geologists as to the prospects for oil at Roma, the writer made a recommen-

[1] "Queensland Government Mining Journal," 15th Oct., 1914, p. 519.

dation to the Mines Department that the question should be submitted to geologists of distinction in oilfield work in London before entering on any expenditure. This recommendation appears as No. V. of this issue. The question has consequently been discussed by geologists of such distinction in this class of work as Dr. A. C. Veatch, Mr. P. Charteris A. Stewart, and Mr. W. H. Dalton, F.C.S., F.G.S., all of whom are, as seen by their reports, impressed with the significance of the occurrence on the prospects for oil. Dr. Veatch, in his first report (No. VI. of this issue), agreed with the writer's opinion that the prospects are promising, and in his second report (No. XII. of this issue) combated in detail Mr. Carne's five reasons for considering the prospects unpromising. Mr. Dalton (No. XVI. of this issue) pronounced the gas as "palpably oil gas."

In accordance with these favourable reports the Government decided to undertake boring operations to prospect the beds.

The proposition of the methods to be adopted to prove the beds as distinguished from the question of the prospects for oil has also been faced with considerable difficulties, on account of the great depths to be reached (about 3,700 ft. to the gas stratum) and the lack of knowledge of geological structures which would indicate favourable positions for boring. This has led to further lengthy correspondence with the experts consulted in London. The conditions at Roma are probably unique in the history of oilfield development from the fact that probably in no place in the world has country lying at over 3,700 ft. below the surface been required to be proved without fairly definite knowledge of the structure of the beds to be prospected and of the position of the oil stratum expected to be reached. This knowledge it is impossible to gain at Roma from the exposures at present available. The original proposal contained in a letter from the Agent-General (No. IX. of this issue) was to make use of a rotary mud-flush drilling plant. This was afterwards discarded by Sir Boverton Redwood—in whose hands this matter had been placed for advice—in favour of diamond drilling in order that the structure of the gas-bearing beds may be determined in accordance with the recommendation of Mr. W. H. Dalton, the geologist finally consulted on the geological aspect of the methods of prospecting.

Mr. Dalton recommended a series of deep bores (to over 3,200 ft. in every case), having discarded a recommendation of the writer's—that suitable structures should be tried for by a series of shallow bores before deciding on a position for a deep bore—on the grounds of a probable unconformity between the upper beds and the gas belt.

A further difficulty was experienced by the Government in securing the services of a competent engineer with experience in boring for oil to take charge of the work as finally recommended by Sir Boverton Redwood and Mr. W. H. Dalton, but this has now been met by entrusting it to Mr. John Hargreaves, Acting Hydraulic Engineer, and by despatching him to America to allow of his becoming acquainted with the latest methods of cementing bores against heavy flows of water, and of dealing with heavy inbursts of gas, and caving strata at great depths, conditions which gave repeated trouble in the two previous deep bores, and are likely to again if unskilfully handled.

The difficulties of the problems involved in designing means for economically and exhaustively testing these beds for oil are made apparent by these reports. If the area is to be tested with a minimum of dry holes and unnecessary expense, it seems requisite that the operations should be undertaken by an authority having the control of a wide area of country, so as to give facilities for choosing sites for boring on a definite plan. The decision of the Government to undertake this work themselves should probably allow of this being done in the most systematic and economical manner possible, as they will be in a position to command greater facilities for locating suitable sites, than will any private company confined in its choice by comparatively small areas.

The history of the steps of these protracted preliminary inquiries and discussions is as follows:—

In 1897 a bore was put down at Roma by the Hydraulic Engineer, and struck flows of artesian water between 907 ft. and 1,022 ft., and between 1,170 ft. and 1,360 ft., and in 1899 a second bore was put down with the object of increasing the available supply, and struck the same supplies at the same depth. These two bores became known as the No. 1 and No. 2 bores, respectively.

In 1900 the No. 2 Bore was deepened with the object of securing additional supplies of water, and struck a flow of natural gas at a depth of 3,683 ft., the amount of gas being measured as 39,411 cubic ft. per diem.

The gas was allowed to escape from this bore for over four years, when a movement was made by the Roma Town Council to have the gas utilised for lighting purposes, and the flow was again measured in April, 1904, by the Hydraulic Engineer and gave a flow of 70,000 cubic ft. per diem. A gasometer was built and the streets reticulated and lighted for about ten days, when

the flow of gas suddenly diminished to such an extent that the lighting scheme had to be abandoned, and the plant has been idle ever since.

The importance of this occurrence of natural gas on the prospect for the occurrence of oil led to the formation of the Roma Mineral Oil Company, and the assistance of the Government was invoked for the purpose of prospecting for that mineral. A report on the prospects was called for from the writer and was furnished in November, 1904, and appears as No. II. of this issue.

In July, 1907, boring was commenced by the Roma Mineral Oil Company, with the assistance of the Government, at a distance of about 250 ft. south of the No. 2 or Gas Bore, and struck a heavy flow of gas at a depth of 3,702 ft. on the 27th October, 1908. The gas caught alight from the boiler fire within a few minutes afterwards, and was not extinguished till the 11th December. On resuming boring, the gas suddenly shut off, owing, probably, to caving of strata or flooding of water at the bottom of the bore. This bore is known as the Roma No. 3 Bore or oil bore.

An illustrated account of the means adopted to extinguish this fire was published in the "Queensland Government Mining Journal" for January, 1909, and is reprinted as No. III. in this issue.

Attempts to sink this bore below the gas zone proved a failure owing to the jamming of the tools in soft "running" strata, and on 22nd March, 1910, the bore had to be abandoned, with three sets of tools in the bottom of the hole.

The striking of gas a second time at about the same depth in even greater volume, after the flow in the No. 2 Bore had shut off, indicated the probability of considerable supplies in these strata, and led to renewed interest in the question of the possibility of its being connected with reservoirs of petroleum.

In September, 1911, the writer was instructed by the Hon. the Minister for Mines to furnish a report "On the prospects of discovering oil by further or deeper boring at Roma," and this report appears as No. IV. of this series, and contains a record of the nature of the occurrence of gas met with in the No. 2 and No. 3 bores at Roma, and of the strata passed through and the difficulties met with in the drilling as far as the information could be gathered from those concerned in the drilling or had been recorded.

In July, 1912, the Hon. the Premier gave instructions to the Mines Department to prosecute a thorough investigation into the possibilities for oil of the Roma district, and the writer accordingly made a recommendation that the available information should be placed before petroleum experts in London, and if a favourable opinion were obtained that an experienced oil-well engineer should be engaged to design and execute a scheme of prospecting by drilling (No. V. of this issue).

The Agent-General in London was accordingly instructed to this effect, and consulted with Lord Cowdray, Chairman of the Mexican Eagle Petroleum Company, and Sir Boverton Redwood, President of the Institute of Petroleum Technologists in London. Reports were obtained from Dr. A. C. Veatch, late of the United States Geological Survey, and now Consulting Geologist to Mexican Eagle Petroleum Company, and from Dr. Wm. Hope Henderson, of the firm of Henderson, Henderson, and Higgins, Consulting Mining Engineers, of London.

These reports appear as Nos. VII., VIII., and IX. of this issue, and were all favourable to the prospects for oil at Roma.

The Agent-General's letter of 7th January, 1913 (No. VII.) contained a suggestion for the employment of the Rotary mud flush system of drilling, and the engagement of drillers expert in this class of work from America.

On these reports being submitted to the writer it was recommended that the suggestion for the employment of the Rotary system of drilling be referred definitely to an expert oil-well engineer before final adoption, as all the information available in Queensland was not favourable to the employment of this method for preliminary prospecting work. This recommendation, together with some additional information gained during the interim, appears as No. X. of this series.

In June, 1913, a report on the occurrence of petroleum in Papua by Mr. J. E. Carne, Assistant Government Geologist in New South Wales, was brought under the notice of the Mines Department by the Hon. the Premier, as in it were references adverse to the prospects for oil at Roma. These remarks are quoted in a memo. by the writer (No. XI. of this issue) in which a recommendation was made that they be referred to Dr. Veatch for his opinion.

No. XII. of the series is a long report by Dr. Veatch, in which Mr. Carne's comments are traversed in detail, and the prospects for oil again summed up in favour of the ground being tested. A recommendation was also made for a detailed

examination of the district around Roma in order to elucidate the minor details of its geological structure before initiating boring.

No. XIII. is a memo. by Mr. Charteris A. Stewart, to whom Mr. Carne's remarks were also submitted, and is mainly corroborative of Dr. Veatch's recommendation for a detailed geological survey of the district.

These recommendations for geological work were dealt with in Nos. XIV. and XV. of this series, wherein it was suggested that the information required by Dr. Veatch and Mr. Stewart could best be obtained by a series of shallow bores, as the character of the outcrops at Roma would not allow of the geological structure being worked out in sufficient detail to allow of determining promising positions for boring.

On the writer's recommendation for preliminary shallow boring being brought to the notice of Sir Boverton Redwood, it was submitted by him to Mr. W. H. Dalton, Consulting Geologist in London. No. XVI. of this issue contains an opinion that the structure of the gas-bearing zone could only be determined by a series of four or five deep bores to at least 3,200 ft. depth, on the grounds that the gas occurs in rocks of permo-carboniferous age unconformably underlying the trias-jura beds and that boring into the upper beds alone would thus not elucidate the structure of the beds to be prospected for oil.

Nos. XVII. and XVIII. of this series are letters from Sir Boverton Redwood endorsing Mr. Dalton's recommendations for a series of deep test bores, and recommending the employment of the diamond drill in order that cores of the rocks may be preserved, and the structure of the country thus more satisfactorily elucidated.

No. XIX. of this issue is a memo. from Mr. L. C. Ball, Assistant Government Geologist, to the Under Secretary for Mines, which, although not agreeing with Mr. Dalton's interpretation of the drill records, endorses generally his recommendation for deep-test bores.

No. XX. is a final recommendation from the writer that the execution of the work should be placed in the hands of an engineer competent to deal with the difficulties in boring likely to be met with.

II.—REPORT ON THE SIGNIFICANCE OF A FLOW OF GAS IN THE ROMA No. 2 BORE.

By W. E. Cameron, B.A., Assistant Government Geologist.

Brisbane, 30th November, 1904.

The Roma Bore, No. 2, was put down for artesian water, and struck a fair supply between depths of 750 ft. and 1,360 ft. The bore was deepened in the hope of adding to this supply, but no result followed until it had reached a depth of 3,683 ft., when a flow of gas with some water and mud was struck, and boring was discontinued. The last thousand feet of boring having been lined with 5-in. and 4-in. casing, and the upper portion with 6-in. to 10-in. casing, the flow of gas has been kept from contact with the water by leading it to the surface by the smaller tubing, and allowing the potable water from shallower depths to ascend round it in the larger casing.

In February, 1901, the amount of gas flowing from the lower levels was measured by Mr. J. B. Henderson, Government Hydraulic Engineer, as 39,411 cubic feet per twenty-four hours. The gas has been allowed to waste freely since, and in April, 1904, was again measured, with a view to supplying the town, and showed a flow of over 70,000 cubic feet per twenty-four hours. The increase in flow of this natural gas in the beds beneath Roma has led to the hope that these may also contain oil.

Geological Considerations.

In a report written for the British Association in 1891, Mr. W. Topley, F.R.S., thus sums up the conditions under which petroleum and gas occur in quantity, and his conclusions are no doubt in accordance with the numerous special reports on the various important gas and oil fields of both the Old and New Worlds. Mr. Topley says, among other things—

"1. The most productive areas for oil and gas in great quantity are where the strata are comparatively undisturbed. Oil, but in less abundance, frequently occurs when the strata are highly disturbed and contorted, but gas is rarely so found.

"2. The main requisites for a productive oil or gas field are a porous reservoir (sandstone or limestone) and an impervious cover.

"3. Both in comparatively undisturbed and in highly disturbed areas, an anticlinal structure often favours the accumulation of oil and gas in the domes of the arches.

"4. Brine is an almost universal accompaniment of oil and gas."

Taking the second of these conditions first, the beds in which the gas flow has been found in the Roma bore, as far as the evidence is available, show a good prospect of fulfilling the condition.

The bulk of the evidence points to the conclusion that these beds belong to the Trias-Jura system, and are identical with those found cropping out over a wide belt of country to the north of Roma, about 10 miles north of, and running parallel with, the Western Railway Line. These beds were mapped some years ago by Mr. Maitland, late Assistant Government Geologist, and were shown to dip south towards the railway line. They are succeeded by the beds of the Lower Cretaceous system, into which they pass upwards without any apparent unconformity, the division between the two formations having been placed by Dr. Jack at the bottom of the porous water-bearing sandstones, known as the Blythesdale braystone. These latter are found cropping out to the south of the Trias-Jura beds, from 4 to 10 miles north of Roma, and are supposed to be identical with the main water-bearing strata which have since been tapped at from 750 ft. to 1,360 ft. in the Roma No. 2 Bore. They thus dip south at the rate of from 150 ft. to 200 ft. in the mile.

The Trias-Jura beds in which the gas has been found dip under these beds without any apparent unconformity between the two formations. They have not been studied in detail in this district, but from what is known of them they seem likely to fulfil the conditions of storage capacity enunciated by Mr. Topley. They are known to contain numerous more or less porous sandstones, which could act as reservoirs for oil and gas, and they also contain beds of impervious clays and shales which would serve the purpose of confining any supplies which might be introduced into them.

The first condition instanced by Mr. Topley—viz., of comparative freedom from disturbance—is a fairly well authenticated feature of the Trias-Jura beds within this area. Such disturbances, by fracturing the rocks and by destroying by pressure and alteration of texture the porosity of the sandstones, would allow of the gradual escape to the surface of any supplies of gas and oil that might be formed.

As regards the third condition of anticlinal folding, often occurring to favour the accumulation of gas and oil in large quantities, there is no evidence, so far, of any such structure in the gas-bearing beds at Roma. This condition, however, has not been proved to be universally present where large accumulations occur. A notable example of this is the Texas Oil Field,[1] in the United States, where the beds have, so far, been found to dip regularly and gently in one direction. In this case the reservoirs are apparently lenticular beds of porous sandstones, interbedded in a mass of impervious shales which have prevented the escape of the gas and oil.

These conditions perhaps resemble more closely than those of any other field the conditions prevailing at Roma.

The only respect in which the Roma occurrence seems to be unique is in the absence of brine as an accompaniment of the gas. The bearing of this peculiarity of gas and oil occurrence is not very clear. There seems, however, to be no relation genetically between the two substances, and it is perhaps merely a coincidence that up to the present no important deposits of oil and gas have been found without an accompaniment of salt water.

Methods of Prospecting of the Roma Beds for Oil.

In this connection, it may at the outset be noticed that gas has not infrequently been found without any subsequent flow of oil, many gas-producing bores in the great gas fields of the United States having shown no signs of oil even after several years of pumping. On the other hand, the two products are nearly always found in the same strata, and very frequently in the same bore. Their occurrence is apparently due in all cases to an identical series of causes, but, owing to their different densities and powers of diffusion through the rock mass, they have often been separated from each other into separate reservoirs. Where they are found together the gas has, as a rule, been struck first, and the oil has appeared after the exhaustion of the gas, or by an increased facility of percolation in the immediate neighbourhood of the bottom of the bore. The latter effect is brought about either naturally, and gradually, by the opening up of the rock by the continued rush of the gas towards the bore, or artificially, and rapidly, by breaking up the rock at the bottom of the bore by torpedoing with large charges of explosives. The same result would also be brought about by deepening the bore. In the case of the Roma bore, this ap-

[1] Bulletins U.S. Geolog. Survey—No. 184, p. 48; No. 282, p. 58; and No. 429, p. 26.

parently could only be done at great risk of losing the bore, which would deprive Roma of its supply of water, and would necessitate the sinking of another well.

In the Kansas [1] Field the productive areas occur in detached belts of from 5 miles to 20 miles across, their extent being apparently determined by the horizontal extent of the sandstone beds which act as reservoirs for the gas and oil. In each area the oil is found more abundantly in the wells lying further to the dip of the beds, and the salt water is found in greater abundance in the wells still further to the dip. The application of this experience to the prospecting for oil under Roma is that oil is more likely to be found to the south of the present bore, since, as far as can be judged at present, the beds dip in that direction. To prospect in this direction would necessitate the sinking of another bore, and would be a costly undertaking, as the well would have to be at least as deep as the present one—viz., about 3,700 ft. According to Mr. J. B. Henderson's report for 1901, this bore cost £6,000.

There is still another method in which the prospecting of these beds for oil might be prosecuted. They have been proved almost beyond doubt to rise towards the north, and consequently could be met at gradually shallower depths in that direction. There seems to me no geological reason why there should not occur in these shallower depths other areas containing gas and perhaps oil. In this case prospecting in this direction would resolve itself into a series of blind stabs, unless surface indications should prove to give some indication, on close examination, of the presence of gas. It would be useless to initiate prospecting by sinking trial bores here without being prepared to put down a number of bores with perhaps no result. The depth to which it would be necessary to go to reach the gas-bearing formation found at Roma would be fairly definitely defined after one or two bores had been sunk, and the records compared with each other and with those of the Roma bore. If oil were found in these shallower beds it could be developed at a much less cost than at the great depths near Roma, and the oil could be piped to the railway line at a trifling expense.

Conclusion.

As far as the evidence shows at present, there seems no geological reason why oil in large quantities should not be found in the Roma district, and at much shallower depths than those at which gas was struck in the Roma bore. The occurrence of this gas in quantity is a hopeful indication that deposits of

[1] Bulletin U.S. Geolog. Survey, No. 184, p. 16 *et seq.*

oil also occur. The oil might be searched for by further sinking the present bore, or preferably by sinking a fresh bore a little to the south of the present one. If the determination is taken to thoroughly prospect the country, it would be necessary to sink trial wells at places to be determined on to the north of Roma, where the same beds as carry the gas at Roma can be met with at increasingly shallower depths. In this case, though the cost of sinking to reach the same beds would be considerably lessened, any areas of gas or oil might be easily missed, and the expense incurred before the beds could be thoroughly tested might easily exceed the cost of finding oil near the present bore.

Geological Survey Office, 30th November, 1904.

ADDITIONAL NOTES.

The gas found in the Roma No. 2 Bore was analysed at the Government Chemical Laboratory in 1901, and gave the following results:—

	Per cent.
Carbon dioxide	1·5
Carbon monoxide	5·8
Benzene series	5·0
Olefin series	1·5
Paraffin series (including ethane, 9·8 per cent.) ..	82·4
Nitrogen and residual gas	3·4
Oxygen	·00
Hydrogen	·00

The Government Hydraulic Engineer, in his annual report for 1900-1901, says:—

"A chemical and photometric measurement of this gas in its natural conditions shows that it is an excellent illuminant of 24-candlepower, some 50 per cent. better than the London 16-candlepower standard. A tender has now been accepted for the reticulation of the town of Roma with pipes for the supply of this gas to the ratepayers, and the service will shortly be installed."

In the United States of America the quality of the oil found on the various fields has been found to correspond in character with that of the gas in the same beds, so that if oil is ever found in these beds it may be expected to be of high illuminating quality with a paraffin base. This quality will be an important factor in the prospects of profitable disposal of the oil, as it implies a greatly reduced cost in refining for the higher-priced illuminants as compared with that incurred in treating the lower-grade oils with asphalt as a base.

The finding of a continuous flow of gas in these upper beds of the Trias-Jura system opens out a vista of great possibilities. These beds occur over a wide belt of country extending in crescent form from near Warwick and Killarney on the south, northerly through Dalby and Chinchilla on the western lines, and then north-westerly to the divide between the Dawson and Maranoa Rivers to the north of Roma and Mitchell. None of this country has as yet been pierced by bores to any depth except by the one bore at Dalby, which is 1,841 ft. deep in beds of Trias-Jura age, and the No. 2 Bore at Roma, which entered the Trias-Jura beds at a depth of about 1,360 ft. below the surface and struck the gas at 2,700 ft. The whole of this country accordingly shows as good a prospect of carrying gas and oil as did the country about Roma before it was proved by an accidental boring to great depths. It is quite within the bounds of probability that many other areas of gas, and perhaps of oil, will be located within the district underlain by these beds. At present we know of no indications which would serve as a guide in prospecting these beds, so that if the experience of other countries can be taken as a guide, it is probable that many dry holes will have to be sunk before any portion of the territory can be proved to be valueless as a repository of gas and oil.

Brisbane, 29th December, 1904.

[*Photo., G. Pittman.*

FIG. II.—MINERAL OIL COMPANY'S BORE AT ROMA.

View taken within Half-an-hour of Ignition of Gas, and just after Collapse of Derrick.

III.—EXTINGUISHING THE FIRE AT THE ROMA No. 3 BORE.

(From the "Queensland Government Mining Journal," 15th January, 1909.)

In January, 1907, the Intercolonial Boring Company, Limited, of Brisbane, entered into a contract with the Roma Mineral Oil Company, Limited, to sink a bore at Roma for artesian water, natural gas, or petroleum oil, the work to be started within six months, and to be continued until the bore should reach a depth of 4,500 ft. The Mineral Oil Company in their undertaking were assisted by a subsidy from the Mines Department, on the basis of £1 for £1, up to £2,500.

The Intercolonial Boring Company moved their boring plant from Ulumbie, near Walgett, New South Wales, where they had completed a bore for the New South Wales Government, and erected it on the site. Boring was started in July, 1907, work being carried on day and night in two shifts of twelve hours each, under the supervision of the head driller, Mr. F. W. Taylor. The bore was sunk and cased with 10-in. National casing to a depth of 206 ft., then with 8-in. National casing to a depth of 1,440 ft., where it was set on a seat on hard rock met with at that depth. The lower portion of this casing was perforated with $\frac{3}{8}$-in. holes for 200 ft. of its length, to let in the flows of artesian water met with between 920 ft. and 1,340 ft. below the surface, the flows aggregating 150,000 gallons per diem. A connecting piece was then put on at the surface, joining together the two casings now in the bore. Boring was then continued, and 6-in. National casing put in to a depth of 3,686 ft. below the surface, where it was set on a hard rock seat, shutting off all the artesian water from the inner part of the bore, and allowing it to flow between the 8 and 6 in. casings to the surface, the bore being dry for a clear flow of gas, which was shortly expected.

As the bore deepened the strata of shale caved in, making it necessary to put in a string of 5-in. National casing. This having been inserted, boring was continued until, on 27th October, 1908, when at a depth of 3,702 ft., a very large flow of natural gas was struck, estimated at over 1,000,000 cu. ft. per day, with a pressure 200 to 300 lb. per square inch. The gas rushed from the bore with such force against the walking beam

FIG III.—ROMA BORE FIRE BY NIGHT. [*Holloway, photo.*

View taken shortly after Fire broke out.

that it stopped the engine from working and, striking against the walking beam, caused it to spread. The wind carried it under the shed covering the plant to the steam boiler, where it quickly ignited and burned with great ferocity. The derrick, which was made of angle steel, softened with the intense heat and collapsed, falling over the draw-works, both being destroyed.

The noise of the gas rushing from the bore could be heard a mile away, and at night the fire could be seen many miles distant. Roma was in a state of great excitement, and crowds visited the scene both day and night. People travelled many miles, while some journeyed over 1,000 miles to see the largest gas bore ever struck in Australia. The heat from the fire was so great that no one could approach nearer than 80 ft. without a shield.

Mr. B. L. Schooley, the manager of the Intercolonial Boring Company, Limited, left Brisbane on 30th October for Roma, for the purpose of devising means for extinguishing the fire. It was found that the burning of the walking beam released the drilling clamps, allowing them to be pulled tightly into the top of the 5-in. casing by the string of boring tools, and about 3,680 ft. of drill cable, weighing approximately 2½ tons. This clamp had the effect of spreading the flames into three parts, one shooting vertically, and the others to either side. Gas also issued between the 5 and 6 in. casings, making a mass of flame about 50 ft. wide and 30 ft. high. Mr. Schooley, having had a large experience with fires in oil wells and oil refineries in Canada, after considering all the conditions at the Roma bore, decided on a scheme for extinguishing the flames which eventually proved satisfactory.

The plan included an iron hood or cap, made 6 ft. by 6 ft., and 8 ft. high, with a 10-in. diameter pipe, 20 ft. long, extending from the top, and an outlet, 6 in. diameter and 40 ft. long, extending from the side 5 ft. above the bottom. The pipes were provided with quick-acting balanced butterfly valves, with levers attached to their gudgeons, which extended through the pipes. The steel plates of the hood were bolted to angle irons, and the joints were carefully packed with asbestos to prevent burning. The hood was of large dimensions, for the purpose of covering the whole bore head, including the casing clamps attached to the several strings of casing, and to allow the gas to expand and waste its force before passing out through the 10-in. pipe.

To place the hood over the bore head, the boring plant was put to as much use as possible, the derrick, which is 52 ft. high, being specially adapted for the work. This was erected about

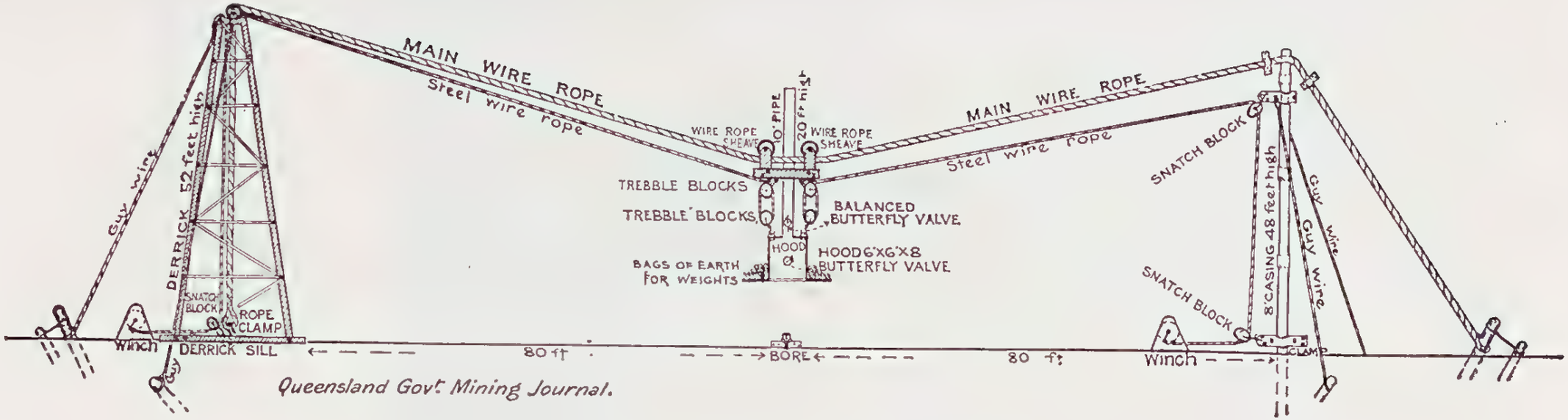

FIG. IV.—EXTINGUISHING ROMA BORE FIRE.

Sketch Showing General Arrangements.

80 ft. from the bore, and was stayed with three guy wires securely fastened to anchor posts in the ground, while two crown sheaves were placed on top to run the wire cables over. A standard was erected at a distance of 80 ft. on the opposite side of the bore, made of 8-in. National casing, 5-16 in. thick

[*Holloway, photo.*

FIG. V.—ROMA BORE FIRE EXTINGUISHER.

Hood being moved towards Bore.

and 54 ft. long. A casing swivel was screwed in the top; the steel wire cable, 2¾ in. circumference, having a breaking strain of 22 tons, was passed through the holes in the swivel, and was protected by a piece of pipe bent to the proper angle. The wire

cable, securely clamped on either side, was extended on, and fixed securely to, an anchor post in the ground; two guy wires were placed at right angles to the main wire cable, and secured to posts; while the other end of the wire cable was passed over one of the crown sheaves on the derrick and down to a snatch-block at the base, thence to a double-purchase winch. With this the standard was hoisted into position, and the guy wires were made fast, the main rope being used to carry a traveller. The winch was then made available for other work by clamping the wire cable. Care was used to have the wire cable of such height that the flames did not injure it, and that it would be below the flames at the top of the pipe when the hood should be placed in position. A traveller was made to run the main wire cable. It was composed of two sheaves, hangers, a distance piece, and a bracket, to support the top end of the 10-in. pipe. Two treble blocks were hung to either end of the traveller, and were connected to two others attached to lugs on either side of the top of the hood, and connected by steel wire cables 1¾ in. circumference. One cable was passed over the second crown sheave on top of the derrick, thence to the base through a snatch-block and to the double-purchase winch. The other was passed through a block at the top of the standard, thence to a snatch block at its base, and connected to another winch. When this arrangement of cables and blocks was completed it was found to be quite easy to raise or lower the hood, or move it back or forward. The hood was placed at the derrick ends of the line, raised a few feet, and moved a short distance towards the bore, then lowered, and additional weight put on by placing bags of earth on brackets attached to the hood, making a total weight of about 2½ tons.

All was now ready to place the hood over the bore. Two men were placed at each winch. Mid torrents of rain the signal was given to wind up the winches, and the hood began to rise. One winch was then reversed, and the hood moved towards the bore head, until it was directly over it. Four guy wires, which were attached to each corner of the hood, were then made fast to posts previously provided, to prevent it being forced away by the force of the gas. Both winches were then reversed, and the hood lowered over the bore, muffling the noise considerably. The critical moment had now arrived. The flow of artesian water washed the soft earth away, and allowed the gas to escape from the bottom of the hood. Attention was directed to weighting and banking up the hood, and many willing hands assisted in placing the bags of earth that had previously been filled on

the embankment, raising it to such height as to shut off all gas and fire from below. The gas escaping from the top pipe soon caught fire, and the flames at that point increased as they decreased below. After the windward sides were banked, the rain ceased and the wind reversed, allowing the workers to bank the other sides. The flames were eventually got under control, and

[*Holloway, photo.*

FIG. VI.—HOOD WHEN DIRECTLY OVER FIRE

burned only at the outlet of the 10-in. pipe, lighting up the country for a mile around. Rain again fell in torrents, and the workers, tired, wet, and hungry, took time to have a spell and have their dinner. When the rain eased up a little the side outlet pipe was bolted on, the valve was opened, and the gas without

any flame rushed out, and in less than a minute the valve in the 10-in. upright pipe was closed. The flame that had been issuing from the top appeared to float away on the breeze, and all was intense darkness. The escaping gas was now completely under control, leaving the way clear for preparations to be made for resuming the sinking of the bore and the ultimate completion of the contract.

FIG. VII.—ROMA BORE UNDER CONTROL.

Fire coming out of Top of Outlet immediately before being Extinguished.

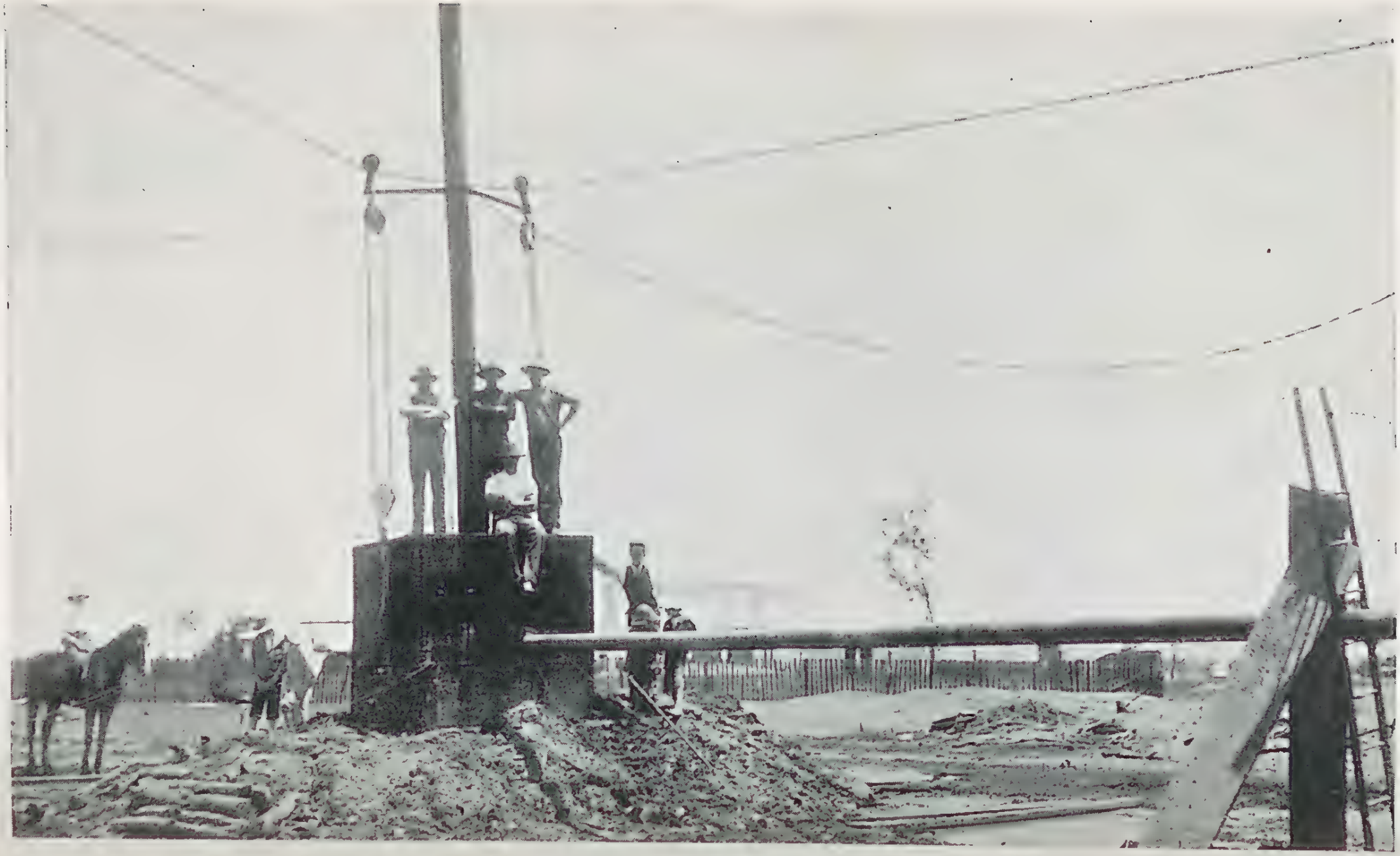

FIG. VIII.—ROMA BORE FIRE.

Holloway, photo.

IV.—REPORT ON THE PROSPECTS OF DISCOVERING OIL AT ROMA BY FURTHER OR DEEPER BORING OPERATIONS.

By W. E. Cameron, B.A., Assistant Government Geologist.

Brisbane, 19th September, 1911.

I.—Discovery of Gas by Boring at Roma.

Two bores, situated about 80 yards from each other on the Municipal Council Recreation Reserve at Roma, struck heavy flows of gas at depths of about 3,700 ft. from the surface. The first bore was sunk by the Government, under the supervision of Mr. J. B. Henderson, Hydraulic Engineer, on behalf of the Roma Town Council, in an attempt to increase the supply of artesian water for the town, and struck the gas on the 16th October, 1900, at a depth of 3,683 ft. This gas flowed to waste at a rate of from 44,000 to 70,000 cubic feet a day for four and a-half years before it gave out. The second bore was sunk by the Roma Mineral Oil Company to prospect the beds below this point for oil, and was subsidised by the Government. It struck a very heavy outburst of gas on the 27th October, 1908, at a depth of 3,702 ft. from the surface, the gas immediately afterwards taking fire and burning with a fierce flame, which destroyed the iron boring derrick within a few minutes. This fire was not extinguished, and then only with very great trouble, until the 11th December. The flow of gas stopped suddenly on 27th January, 1909. The first bore was stopped at a depth of 3,709 ft. 8 in., owing to the pressure of the gas interfering with further drilling; the second was abandoned after a depth of 3,713 ft. had been reached, owing to the jamming of the tools in the soft caving strata in which the gas was struck. The first bore is now known as the Gas Bore, and the second as the Oil Bore.

II.—Geology.

A section of the strata passed through in the Roma Town Council's Gas Bore, published by the Government Hydraulic Engineer, shows that shales were passed through for the first 500 ft. These are considered to belong to the Lower Cretaceous Formation, as fossils of that age have been found in what is no doubt a continuation of these beds at Wallumbilla Creek, 24 miles east of Roma. (See Jack and Etheridge's "Geology of

Queensland," p. 390.) From 500 ft. to about 2,000 ft. alternate clays and sandstones were passed through, with one seam of coal at 740 ft., and several flows of artesian water, amounting in all to nearly 200,000 gallons per twenty-four hours, between 900 ft. and 1,400 ft. These flows of water occurred in thick beds of sandstones from 910 ft. to 1,092 ft., and from 1,267 ft. to 1,360 ft. These sandstone beds possibly represent the basal beds of the Lower Cretaceous Formation, which have been mapped on the Geological Map of Queensland as the Blythesdale Braystone, and have been described by Dr. Jack in Bulletin No. 1 of the Geological Survey of Queensland, entitled "Artesian Water in the Western Interior of Queensland." On the other hand, they may be—or at least some portion of them may be—part of the coal-bearing Trias-Jura Beds which are found underlying the Cretaceous Beds to the north and east of Roma, as they are succeeded in the bore by beds carrying several seams of coal, and which, no doubt, belong to the Trias-Jura Formation. Below these coal-bearing strata is a bed, about 360 ft. thick, of sandstone followed by 350 ft. of clays and sandstone. In the former of these a slight increase in flow of water was noticed by the driller of the gas bore. These sandstones probably represent the basal beds of the Trias-Jura System, in which case it would seem likely that the bore below this has passed into the Permo-Carboniferous[1] System of rocks, the marine organisms of which may have been accountable for the formation of hydrocarbon products and for the evolution of the gas. The gas was struck, according to the driller's account, in "grey shale and mud," but if this description of the strata is correct, this shale must have possessed a fairly high degree of porosity, probably by being fractured or by being originally highly calcareous, to allow of the accumulation of the large quantities of gas that must have been stored in it to give a flow of from 40,000 to 70,000 cubic feet a day for four and a-half years. It is unfortunate that there is no other description of the character of this gas-bearing rock than that given by the driller.

I have been unable to get a complete record of the strata passed through in the Oil Bore, but the engineer in charge reported a bed of "fine sandstone similar to bath stone" between 2,790 and 3,065 ft.,[2] which corresponds well in position

[1] The subsequent securing of the driller's log of the strata met with in the Oil Bore and its comparison with that of the Gas Bore (See Fig. X.) discounts the supposition that the bores passed out of the Trias-Jura Beds into unconformably underlying Permo-Carboniferous beds.

[2] These figures were taken from a report by the supervising engineer. A full driller's record was subsequently obtained from the contractors which gave this sandstone as occurring in the No. 3 or Oil Bore from 2,719 ft. to 3,081 ft. See No. X., page 63, and sections of strata referred to. W.E.C.

and fairly well in thickness with the thick bed of sandstone from the 2,718 ft. to the 3,081 ft. in the Gas Bore. Below this were alternate clays, shales, and sandstones till the gas was struck. The rock in which the gas was met appears to have been a soft caving material a sample of which was forwarded to the Geological Survey Office for examination, by the chairman of the Mineral Oil Company. The sample was too small to make a satisfactory examination for traces of oil. It was a soft brown earthy mud, apparently the result of the pounding up of a soft mudstone or shale. It was practically free of grit, but showed under the microscope minute scattered grains of clear angular quartz in a mass of cloudy felspathic grains. This material could not have been more than 8 or 9 ft. thick, as Mr. Schooley, the manager for the contractors for the bore, informs me that hard rock was again struck before the bottom of the bore at 3,713 ft. was met. I have been unable to obtain a sample of this rock, so can form no opinion as to its possibilities as a reservoir for oil.

It seems likely, however, that the rock reported as "grey shale" by the driller as occurring at the bottom of the Gas Bore and the hard rock reported by Mr. Schooley as having been struck below the soft caving sandstone in which the gas was struck at the bottom of the Oil Bore were the same rock. It seems likely that it was either a hardened and highly fractured shale or possibly a more or less porous limestone, as either of these rocks would be a favourable medium for the occurrence of reservoirs of gas. They would not be as favourable for the occurrence of very large quantities of oil, though considerable quantities of oil are occasionally found in hardened and fractured shales, and limestones, where very open and porous, frequently contain commercially valuable stores of oil.

The following is the result of an analysis of the gas from the Roma Municipal Council's Gas Bore, made at the Government Chemical Laboratory in 1901:—

	Per cent.
Paraffin series (including ethane 9·8 per cent.) ..	82·4
Benzine series	5·0
Olefin series	1·5
Carbon monoxide	5·8
Carbon dioxide	1·5
Nitrogen and residual gas	3·4
Oxygen and hydrogen	0·00

This analysis shows that this gas is similar in composition to many of the gases found associated with oil in the oil fields of America and Baku, as given in Boverton Redwood's "Petroleum and Its Products."

The gas from the Roma Gas Bore had a distinct "paraffin" odour on the occasion of my visit to this bore in 1904, when it was flowing freely with the water from the 5-in. casing.

III.—The Roma Council's Gas Bore.

The Gas Bore was originally cased with 10-in. casing to 481 ft. 10 in., with 8-in. casing to 1,232 ft. 9 in., with 6-in. casing to 2,577 ft. 1 in., with 5-in. casing to 3,452 ft. 6 in., and with 4-in. casing to 3,709 ft. 8 in. Artesian flows of water were met with between 700 ft. and 1,400 ft., amounting to 186,000 gallons per 24 hours, and were led to the surface between the 10-in. and 5-in. casing by perforations in the 8-in. and 6-in. casings. A bed of sandstone was passed through between 2,718 ft. and 3,081 ft. which gave a very slight increase in flow. At 3,683 ft. from the surface an outburst of gas and mud occurred, and the following are the driller's notes, kindly supplied me by the Hydraulic Engineer, on the boring at this time:—

"16th October, 1900.—Bore down 3,669 ft. 10 in.

"Tools became fast in hole, causing three and a-half hours' delay. At 1.15 p.m. bore had a blow-up, lasting 20 minutes, throwing mud and water to height of 50 ft. Fumes smell like natural gas; still a quantity of gas coming up at midnight and the early morning.

"Strata passed through: Grey shale and mud. Bored to 3,693 ft. 1 in.

"17th October, 1900.—Bore started to blow-up again at 7 a.m., water being of a milky tint. Pulled out tools, when jet was repeatedly thrown over top of derrick, eventually settling down to intermittent spouts varying from 16 ft. to 25 ft.

"Strata passed through: Grey shale. Bored to 3,709 ft. 8 in."

A 4-in. liner was then lowered to the bottom in order to shut off the gas and prevent the caving of the strata in which it had been first struck. Further attempts to deepen the bore were rendered futile by the pressure of the gas, and an attempt to raise this casing ended in its parting at the 800-ft. level. This occurred in February, 1901, and boring was discontinued, the bottom of the bore, as shown by the driller's reports, being in grey shale, at a depth of 3,709 ft. 8 in., or 26 ft. below the point at which the gas had been struck.

In February, 1901, the amount of gas flowing from the bore was measured by the Hydraulic Engineer as 44,625 cubic feet

per 24 hours, while the amount of water accompanying it was 39,411 gallons per 24 hours. The temperature of this water was 113 degrees F.

The gas was allowed to waste freely for five and a-half years. In February, 1904, the gas was again measured, with a view of supplying the town, and showed a flow of 72,264 cubic feet in 24 hours. In June, 1906, the town was reticulated with pipes and the streets lit with gas. The plant, after running successfully for a few days, was handed over to the Municipal Council by the Hydraulic Engineer on the 6th June, 1906, and householders were preparing to reticulate their houses. On 16th June the gas supply suddenly gave out, and has never since been recovered in any quantity, though a little gas was still reported as coming from the bore as recently as February, 1910.

After the cessation of flow of the gas, water still continued to flow from the 5-in. casing, and, as far as I can learn, is still so flowing. It is impossible to say definitely from what stratum this water is coming, but the driller's report of strata passed through during 16th and 17th October, 1910, shows grey shale and mud between the 3,669 ft. 10 in. and 3,709 ft. 8 in., and it does not seem likely that this material could be the source of an artesian flow of nearly 40,000 gallons per 24 hours during a number of years. It seems more likely that this water was leaking down from a higher source, perhaps from the bed of sandstone between 2,718 ft. and 3,081 ft. that gave a slightly increased flow, and, getting in behind the 5-in. casing, joined with the gas coming up the 4-in. casing above the top of that casing.

There is, of course, the possibility that the driller's report of the strata at the bottom of this bore is incorrect, and that the beds here are of a sufficiently sandy and porous nature to make the term "Grey shale" misleading, and that there is at this depth another artesian flow surcharged with gas that has made its way up from lower strata. It does not seem likely, however, that an experienced driller would make this mistake, and the only reasonable conclusion appears to me that water was leaking into the 5-in. casing from some higher beds. The bore was sunk to 26 ft. 8 in. below the point at which the gas was first struck, and the 4-in. liner was sunk to the bottom of the bore. This would probably cause the greater part of the gas to ascend outside the 4-in. casing, but the fact that the pressure inside the 4-in. liner was still sufficient to prevent further boring shows that the grey shale reported by the driller at the bottom of the bore was sufficiently porous to allow the gas to get into the bottom of that casing.

In 1909 an attempt was made under the direction of Mr. Hamley, Engineer to the Public Estates Improvement Branch, to clear out the bore and recover the flow of gas. Obstructions, in the shape of pieces of iron dropped either by malice or negligence into the bore, were reported to have been met with at several depths, and after repeated efforts to clear the bore the attempt was finally abandoned.

IV.—The Roma Mineral Oil Company's Bore.

The continuous flow of gas from the Gas Bore above described, for so long a period, raised hopes that reservoirs of oil might be found in the same stratum or at greater depths; and in July, 1907, a second deep bore was commenced, 240 ft. south of the Gas Bore, by the Roma Mineral Oil Company, assisted by a subsidy from the Government. The contract was for a depth of 4,500 ft., the contractors being the Intercolonial Boring Company, of Brisbane. Precautions were taken in the contract to stipulate that the flows of water expected between the 700-ft. and 1,400-ft. levels should be admitted into the 8-in. casing, at depths to be decided on, by perforations in the casings, and by seating the 6-in. casing on an impervious stratum. The bore was originally cased with 10-in. casing to 206 ft., with 8-in. casing to 1,440 ft., and on 6th October, 1908, the engineer for the Mineral Oil Company reported that the 6-in. casing was "successfully seated on solid rock at a depth of 3,587 ft. 7 in., thereby excluding the upper waters from getting inside the 6-in. casing." The lower portion of the 8-in. casing was perforated with ⅞-in. holes for 200 ft. of its length, thus allowing the artesian flows between the 700-ft. and 1,400-ft. levels to reach the surface between the 8-in. and 6-in. casings.

On 3rd November, 1908, the engineer reported that the 5-in. liner had been lowered to 3,688 ft. 1 in., and drilling continued to 3,702 ft., when a heavy flow of gas was struck. Within a few minutes this gas caught fire, and burned with such fierceness that in three or four minutes the iron frames of the derrick were softened and the structure collapsed in a heap over the bore.

The gas fire was not extinguished till 12th December, the flames meanwhile having diminished considerably in volume, though they were still too fierce to allow of any near approach to the bore.

In January, 1909, attempts were made to raise the 5-in. casing in order to replace the top length, which had been injured by the fire. During this work the flow of gas, which apparently still possessed considerable force, suddenly ceased altogether, and

the manager for the contractors, Mr. Schooley, has kindly supplied me with the driller's account of how this occurred, as follows:—

"27th January, 1909.—A set of casing dogs with two dogs was inserted to catch hold of the casing about 1 ft. below the top of the casing. It was found impossible to get the four dogs in, owing to the pressure of the gas. As soon as the casing dogs were put in there was a decrease in the volume of gas and water, and while taking a strain of 2 or 3 in. on the casing which would not raise the shoe on the bottom of the casing from its position. The gas then suddenly ceased flowing altogether, after which the 5-in. casing was pulled up and the damaged length of 5-in. casing was removed and a new length inserted in its place, after which two more lengths were screwed on, and the 5-in. casing rested on the bottom of the bore at 3,702 ft."

Boring having been resumed, a soft caving stratum was met with and the boring tools became fast. By the end of October, 1909, as attempts to withdraw the 5-in. casing proved unsuccessful, it was found necessary to cut off the 5-in. casing about 20 ft. above the bottom and withdraw the whole of it above that length. The 6-in. casing was finally got down to the 3,702-ft. level, and the bore was carried down through the soft caving strata to a depth of 3,713 ft., the bottom few feet of the bore, I am informed by Mr. Schooley, the engineer for the contractors, being in hard rock. The tools again got jammed, and finally the bore had to be abandoned with three sets of tools at the bottom.

V.—Significance of Flows of Gas as an Indication of Oil Deposits.

Although gases of the composition and with the peculiar "paraffin" odour of the gas from the Roma Gas Bore frequently accumulate in porous beds not directly communicating with oil beds, large flows of gas of this character certainly point to the conclusion that hydrocarbon-forming agencies were in existence in the locality, and there is a strong presumption in favour of the occurrence of oil in some quantity in the near neighbourhood.

There are numerous instances of bores that have given large flows of gas that have never yielded any oil even on the exhaustion of the flow of gas. On the other hand, where there is a fair continuity of porous beds, wells which have given only gas under high pressure for many weeks have on the diminution of the pressure given flows of oil.[1] In a great many instances prospecting has sooner or later led to the discovery of oil pools, if not in

[1] 21st Ann. Rept., Dept. of Geology, Indiana, p. 483.

the same stratum, at least in associated strata, that have lent themselves more readily to the absorption and storage of large volumes of oil.

Owing to the absence of viscosity in gases and the consequently very great ease of diffusion of petroleum gas through the minute pores and joints in rocks, circumstances frequently arise which allow of the separation by considerable distances of large volumes of gas from the petroleum from which it has been given off. This may entail the sinking of a number of bores in the neighbourhood of a developed gas well before the pool of oil from which the gas emanated is discovered. As a case in point, the history of the discovery of the Bremen Oil Field, in Ohio, as given in a recent report by the State Geologist, is interesting. The first words of that report read as follow ("The Bremen Oil Field," by J. A. Bownocker, State Geologist, Columbus, Ohio, 1910) :—"The discovery of the Bremen Oil Field is a result of the close association of oil and gas. As is well known, every oil well is to a greater or less extent a gas well, and large gas wells are seldom remote from oil." The report subsequently shows that gas was first discovered about 10 miles west of the Bremen Oil Field of Ohio, in the Clinton Sands at Lancaster, at a depth of 1,957 ft., in 1887, and later in the same year at Newark, some 20 miles further north, at a depth of 2,385 ft. A number of wells were drilled for oil in the intervening country with disappointing results (many of them, however, obtaining gas) during the next twelve years, and it was not till 1899 that the first well to strike oil in commercial quantity was completed. It was not till 1907, or 20 years after the first discovery of gas, that the first two prolific wells in the Bremen pool were completed and marked the opening of that pool as a large producer.

VI.—Prospects of Obtaining Oil at Roma.

The above short piece of oil history shows that where the gas or oil strata lie at considerable depths, a long persistence in prospecting by numerous and costly bores may be necessary before an oil pool of any magnitude is located.

The character of the Roma gas-bearing stratum does not, as far as it can be judged by the sample forwarded to this office from the 3,702 ft. in the Oil Bore, and from the driller's description of the strata carrying the gas in the Gas Bore, give promise of being a favourable medium for the storage of petroleum in large quantities, owing to its fineness of grain and seeming want of porosity. All the literature available on the subject, including that of most of the American and Russian occurrences, shows that

commercial quantities of petroleum are almost invariably confined to porous sandstones or incoherent sands, or to porous dolomitic limestones. In a few isolated cases remunerative, though not strikingly large, supplies are obtained from sandy shales, as in the Boulder Oil Field of Colorado,[1] or even from hardened and fissured shales, as in the Florence Oil Field[2] of that State.

There is, however, the possibility that the "grey shale" reported by the driller from the bottom of the Gas Bore is a more porous rock than is generally implied by that term, that the cessation of flow of gas in the two bores was not due to natural exhaustion of the supply, but to caving at the bottom of the bores, or to plugging by mud carried into the bores in the water that issued with the gas, and that if arrangements could have been made to keep the bottom of the bores clear, oil would have made its appearance on the natural exhaustion of the gas. This stratum may also be sufficiently porous in places to carry pools of oil lying at some distance from the present bores, and separated from them by the geological structure of the beds.

There is also the possibility that more porous rocks, capable of holding oil in large quantities, exist below the "grey shale" reported by the driller from the bottom of the Gas Bore, and that the gas already met with in the bores has been thrown off from those deposits, and that, owing to its ease of diffusion and capability of compression into rocks with only a slight degree of porosity, it has been forced into higher beds until blocked by the impervious clays and shales occurring immediately above the point at which it was struck in the two Roma bores.

VII.—Engineering Difficulties.

In this connection it may be noted that in the Oil Bore, which was started 10 in. in diameter, the 6-in. casing was successfully carried down to a depth of 3,687 ft. before it was found necessary to contract the diameter of the bore to 5 in. Severe trouble only began when the soft mud rock carrying the gas below 3,702 ft. was met with, the continual caving of this strata apparently repeatedly jamming the tools and leading to the breaking of the connection with the surface, and to excessive delays in fishing for lost tools. The Gas Bore, however, seems to have successfully got through this caving stratum, as the bottom of the bore was taken to 26 ft. below the point at which the gas was struck, and the 4-in. casing was carried to the bottom,

[1] Bulletins U.S. Geolog. Survey—No. 213, p. 327; No. 225, p. 383; and No. 265, pp. 31-33 and 83-84.

[2] Bulletin U.S. Geolog. Survey, No. 381, p. 521 *et seq.*

the only trouble being the pressure of the gas, to cope with which special tools would have been required. If the difficulties of boring beyond these great depths can be successfully surmounted, there does not seem any reason why petroleum in commercial quantities should not be found and raised from the beds below Roma. The recent publication of the Geological Survey of Ohio above referred to shows that quite a number of wells drilled in the Bremen Oil Field to depths of between 2,600 ft. and 3,000 ft. started flowing oil at from 25 barrels to 250 barrels a day. One well, at a depth of 3,470 ft., started pumping 15 barrels a day; another, drilled to 3,407 ft. began flowing at 10 barrels a day; while a third at 3,290 ft. flowed at 20 barrels a day. These are certainly amongst the deepest producing oil-wells in America, and perhaps in the world, but I know of no geological reason why oil in commercial quantities should not be found at even greater depths, and of no engineering difficulties in profitably raising it from such depths when once the difficulties of piercing the strata have been overcome.[1]

VIII.—Conclusion.

My conclusion from the above considerations is that the probabilities of there being oil in the beds below the neighbourhood of Roma are considerable. The outflows of gas met with in the two Roma bores may be taken as evidence that hydrocarbon-forming agencies of some magnitude existed in more or less close proximity to the strata in which the gas was found, though they are not evidence of the existence of oil in commercial quantities immediately below the situations of the bores. The gas-bearing rocks penetrated by these bores do not appear from the information available to be very favourable to the prospects of their holding large supplies of oil, as that information would indicate an absence of sufficient porosity. As, however, there has been no opportunity of inspecting the samples of these rocks brought up by the drill, except the small piece of mudstone forwarded by the director of the Mineral Oil Company, the information on which this conclusion is based is not very definite, and the two bores so far put down into this rock can hardly be considered as a fair test of its possibilities.

Four possibilities present themselves:—

1. The cessation in the flow of the gas in the two bores above described may have been due to choking of the bottom of the bores, and if either of these bores could be cleared to the bottom

[1] See Dr. Veatch, No. VI., p. 44.

and the flow of gas restored, a flow of oil might follow; otherwise a new bore would have to be sunk, with precautions taken to insure an uninterrupted flow of gas and satisfactory trial of this stratum for oil. A possible flow of oil may have been prevented in these bores by the failure in cutting off all access of water from overlying strata.[1]

2. The gas may have been given off from deposits of oil lying at greater depths in more porous strata, the gas, owing to its greater power of diffusion, having escaped up into the "grey shale" reported by the driller at the bottom of the Gas Bore. This can only be tested by making provision to bore to greater depths than those already reached.

3. The gas may have been given off from oil now collected in a pool or pools lying at some distance from the site of the present bores. In this case it may easily take the expenditure of a very large sum of money in sinking a number of deep and costly bores before a productive oil pool is located.

4. The conditions under which the hydrocarbons have been formed in these rocks may not have been favourable to the production of commercially valuable quantities of oil. The cases in which such conditions arise, however, do not appear to be sufficiently frequent to warrant a pessimistic view of the possibilities on this score.

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[1] See Dr. Veatch, No. VI., p. 45.

V.—MEMO. FOR THE UNDER SECRETARY FOR MINES.

By W. E. Cameron, Assistant Government Geologist.

Ipswich 1st July, 1912.

(*Re* the Hon. The Premier's instructions for a "thorough investigation into the possibilities for oil at Roma.")

My report on the prospects of discovering oil by further or deeper boring operations at Roma contains an account of all the material facts that I was able to collect concerning the character and manner of occurrence of natural gas at Roma, and of the difficulties encountered in the boring operations. It also includes an opinion that the constitution of this gas is indicative of the presence of oil.

The difficulties from caving strata, and from heavy flows of water, referred to in that report are of no mean order, and are such as are likely to tax the ingenuity of even the most experienced engineer, in any attempt to produce a productive oil well.

Although, therefore, I have expressed the opinion that the probabilities of there being oil in the beds below Roma are considerable, I am of opinion that it would be advisable for the Government, before embarking on any further expenditure in boring, to place my report, and any other information required, before an engineer with a wide experience in boring for oil. There are in London engineers whose whole time has for years been devoted to superintending or advising on oil-boring operations, mainly for English companies operating in Russia and the East, and who are conversant with every phase of the business. Among such I may mention Mr. A. Beeby Thompson, author of "The Russian Oil Fields" and "Petroleum Mining," whose works show him to have an intimate and practical knowledge of the details of boring for and marketing oil. It is quite possible that the Agent-General could secure the services of Mr. Thompson, and I would suggest that, as a first step to the thorough investigation desired by the Premier, my report should be submitted to him, or, failing him, to some other engineer with an

extensive knowledge of the practice of boring for oil, and advice obtained on the following points:—

1. A corroboration or otherwise of my opinion that the character of the Roma gas is an indication of its having been given off from oil.

2. Advice as to the possibilities of successfully overcoming the engineering difficulties in producing a productive well, involved in the occurrence of caving strata at great depths, and heavy flows of water, of the character noted in my report, even if petroleum is likely to be present.

3. Advice as to the commercial possibilities of profitably marketing oil raised from such great depths, considering the locality and probable market.

4. The recommendation of a competent engineer with experience in boring for oil, to take charge of the boring operations, if the advice on the previous three points is sufficiently favourable to warrant the initiation of further boring.

VI.—REPORT BY DR. A. C. VEATCH,

Consulting Geologist.

London, 26th November, 1912.

I have read the accompanying reports of Geologist Cameron regarding the finding of natural gas at Roma and the prospects of obtaining oil in that region with great interest. The subject is most completely and comprehensively treated in these reports, as one would expect from a geologist of Mr. Cameron's reputation and ability. In the main I agree with his premises and his conclusions.

While a gas well does not necessarily mean there is oil near by, the finding of gas of this character makes the prospects for oil much more favourable than if no gas had been found.

The great depth indicated is not in itself prohibitive; there are a number of wells in California, 5,000 ft. deep, which are yielding oil commercially, as is likewise true in the Central European Fields. It is neither mechanically impossible to reach such a depth nor does such depth in itself prohibit the occurrence or accumulation of oil, and in the segregation of oil lands by the United States Government, a depth of 5,000 ft. was adopted some two years ago, and there is every probability that this depth limit will be increased.

While the cost of such borings is great, the fact that they have been commercially successful in California, where there is an enormous production (most of it from wells less than half this depth), clearly indicates that such borings in Queensland, where there is no oil production, might be quite successful from a commercial standpoint. The question is really not so much one of depth as it is the quantity of oil that can be obtained. Drilling alone can determine this.

The mechanical difficulties described by Mr. Cameron are not regarded as insurmountable. In the matter of large artesian flows, it may be noted that in all the South Louisiana and Texas developments the oil lies below the large artesian horizons, and, as to caving material, many successful wells in both Louisiana and California are drilled in caving material from top to bottom.

On the point of whether the test bore should be put down by men with wide experience in drilling water wells in Queens-

land or by men who have had experience in drilling for oil in other parts of the world and in other formations, much is to be said each way. The artesian borer who has had long experience in Queensland knows his rocks and knows the conditions of boring there, which is no small asset. In the early days at Beaumont, in the Texas Field, it was the artesian well driller who was successful, and it was the oil well driller from the hard rock regions of Pennsylvania and West Virginia who found his past experience of little use. These artesian well borers developed into the oil well borers of that region. The conditions in Queensland are not entirely analogous, but I cite this as showing that sometimes the artesian well borer's knowledge of local rocks and drilling conditions is of more value than the oil well borer's experience gained where the conditions of drilling and character of rocks are quite different. On the other hand, a well borer with experience in cementing off water-sands and in handling gas pressures in caving material (and not all oil well borers have had such experience) would be of great assistance in dealing with the problems which present themselves at Roma. The best place to look for such a man is in the California Fields, where in some regions the problem of thoroughly cutting off water-sands is often of the utmost importance, and where heavy gas pressures in caving material must be mastered. But the oil well man must have this special experience to be able to serve Queensland in this search for oil better than the Queensland artesian driller of experience.

I do not incline to the view that if the gas were exhausted from the gas yielding zone there is any great probability of it being followed by oil, and, therefore, believe that if oil is to be found, it will be obtained by going deeper or by sinking in some nearby place, indicated by structural conditions to be most favourable for the accumulation of petroleum. Without knowing the minor details of the local structural conditions, I should at first thought say, go deeper.

A matter of particular concern in the development of this region is the question of whether or not the layer which is yielding the gas contains water. In the first well, the gas was accompanied by a large flow of water, and Mr. Cameron, with considerable reason, inclined to the view that this came from an overlying water horizon. But in the second bore, where special precautions were taken to case off water, there still seems to have been water with the gas, though this point is not entirely clear from the report.[1] If the water is coming from above, and

[1] No. VIII., par. (vi.), p. 63.

there is no water in the gas zone, the two holes now existing are allowing water to enter this layer and to seriously depreciate its value. The gas zone has considerable value not only as a source of supply of fuel in the shape of natural gas, but as a source from which various liquid petroleum products could possibly be made by compression and treatment by methods recently applied in the United States. As a precautionary measure, I would suggest the cementing of the lower portion of these wells, although the carrying out of this plan presents several difficulties which it may or may not be possible to overcome.

If the gas layer is not an artesian water horizon, and the water is really coming from the 3,000-ft. sandstone, by passing below the bottom of the 5-in. casing at 3,452 ft. in the first well, it would be possible to fill the lower part of the well by pumping liquid hydraulic cement through a 1-in. or 2-in. pipe extending into the dead water below the inflow point. To make this cementation effective, the 4-in. pipe in the first well would have to be cut at a depth of about 3,500 ft., and the portion above that point either pushed to one side or lifted out. In the second well, the 6-in. casing is reported as reaching to the very bottom, although in the statement of the pushing of this 6-in. casing below the first landing point at 3,587 ft., and the subsequent deepening of the well, one is left in doubt[1] as to what was done with the 20 ft. of 5-in. casing which in the earlier stage of the work was cut off and left firmly embedded in the bottom of the well. If the 6-in. casing does go to the bottom, not much water will get into the gas zone until the decay of this casing, and to minimise the amount, in this event, it might be well to fill the lower 100 ft. of the 6-in. casing with cement, even if it is not possible to cut the 6-in. pipe at about 3,500 ft. and lift it 5 or 10 ft. in order to get a cement contact with the natural walls of the well, which would be more effective.

In future borings for oil, the upper water-sands must be absolutely shut off or successful results cannot be hoped for even if the oil is present.

[1] Fig. X. gives the present positions of the casings in the two bores, the 6-in. casing in this bore (the Oil Bore) having been reported to be all pulled.—W.E.C.

VII.—REPORT BY THE AGENT-GENERAL TO THE CHIEF SECRETARY.

Queensland Government Offices,
409 and 410 Strand, London, W.C.,
7th January, 1913.

Sir,—In further reference to the possibilities of oil at Roma:—

I enclose a copy of a letter addressed to me by Dr. Henderson. I am procuring the publications mentioned therein and will send these along, as soon as received, in the hope that they may be of service.

A point I wish to direct attention to in connection with this letter is, however, the fact that the presence of natural gas (which has been clearly demonstrated) is, in itself, a discovery of the first importance. It is, of course, one of the indications of the presence of oil in its near neighbourhood, but as in some parts of America the presence of gas, without oil, in commercial quantities, has been of sufficient importance to result in the establishment and building of great industrial manufacturing cities, such, for instance, as Pittsburgh, there seems no reason to doubt that if the geological formation is equally favourable the same results might follow in Queensland, if it could be demonstrated that gas existed in sufficient quantities to provide heat and power for industrial purposes on a large scale. It is only necessary to consider what an enormous economy and advantage it would be to the Ipswich workshops if a supply of natural gas were available for power and heating purposes, and what an impetus the existence of such a natural advantage would give to other industrial establishments at that centre, and as you will see from Dr. Henderson's letter, it is found to be worth while to convey natural gas to great distances for industrial and manufacturing purposes.

The industrial application of natural gas is making great headway in Hungary, and the Hungarian Government are now consistently subsidising commercial undertakings that are making extensive search for natural gas alone. They are, in a sense, indifferent to the existence of oil in the neighbourhoods in which search is being made for gas.

Since last mail, through the kindness of Mr. W. K. D'Arcy, I have had the opportunity of discussing the file of papers which you were good enough to send me in connection with this matter with Sir Boverton Redwood, who, as you will doubtless know, is regarded as the leading engineer in the oil industry in this country, and he was greatly interested in the matter and anxious to give me every assistance.

After perusing the reports and the papers, Sir Boverton Redwood said the indications were distinctly favourable, and if his opinion were asked he should certainly consider it well worth while to make a further search for oil in the district. If, after all, oil were not found in commercially successful quantities, reservoirs of natural gas might be tapped, which, in itself, if in sufficient quantity, would more than justify all the outlay involved. He is, however, in doubt as to the sufficiency of the sum mentioned for the purpose of making adequate search, and is inclined to think that the Government should contemplate the expenditure of at least £8,000 or £9,000 instead of the sum named—viz., £5,000. He instanced the fact that in Galicia and other parts of Austria-Hungary wells 4,000 ft. deep, which have cost as much as £2 per foot to bore, have been very successfully operated for years past. In known oil districts—as, for instance, in Russia, bores frequently commence with a diameter of from 24 in. to 28 in., and taper off by degrees to a diameter of 12 or 14 in. at the bottom. Sir Boverton, however, is of opinion that for our purposes it would be quite sufficient if we started with a 16-in. or possibly a 14-in. bore; it is, however, essential that at a depth of 3,000 ft. we should still have a bore of at least 10 in. in diameter. He says that 4 in. is quite inadequate for our purpose, and is not in the least surprised at the trouble which was experienced with a pipe of this size in the Roma bore.

Although Dr. Veatch, whose report Lord Cowdray was good enough to send to me, attaches some importance to the knowledge of local rock which water borers may have obtained by the work which they have carried out in Queensland, I am satisfied by the conversations which I have had with all the gentlemen of experience with whom I have discussed this matter, that more importance should be attached to the concluding paragraph of his report than its brevity would indicate, and that it is of the utmost importance, if the bore is to be successful, that it should be undertaken and carried out by men who have had experience as oil borers. Sir Boverton Redwood was exceedingly strong on

this point, and gave me several instances in which bores in oil country had been unsuccessful because the boring had been undertaken by men who had no experience except of water boring, who had permitted the intrusion of water (generally, of course, from a higher level). In some cases the water appears to have driven the oil quite beyond the reach of the bore; in other cases the mixture of water with the oil entirely spoiled the success of the bores. So much damage has been done in certain fields by the comparatively amateurish methods employed by borers without oil experience that the Governments have been driven to frame regulations prohibiting the employment of inexperienced persons. With the experience of the Roma bore before you, it might be well to keep in mind the advisability of doing something of the same kind in Queensland, if occasion should require it.

Sir Boverton was also good enough to give me particulars of a new rotary drill which is now being very extensively used in the oil fields, and which he tells me is much more economical and effective than any previously employed type of drill. It is called "Parker's rotary drill," and I am in communication with the London agents for this machine. It has been suggested to me that they might be inclined, in order to establish the reputation of the drill in Australia, to undertake the sinking of some such well as that you contemplate, and quote an inclusive price for their services in the matter.

The speed at which this drill sinks is much greater than anything which has been known before, and oil ground has been successfully tested in less than three months, the well in which, two or three years ago, would have taken at least ten or eleven months to bore.

Having regard to the type of country which generally exists between the surface and the situation of the oil or gas, the utmost possible speed should be made, as the risks are in consequence greatly diminished. It is the practice with this rotary drill to work day and night, and it is part of the method to feed the bore immediately behind the drill with a "pugging," or clay-cement mixture, in solution and under pressure, which has the effect while removing the boring debris of filling up the pores of porous rock (often water-carrying) and so preventing the flooding of the bore at points of danger.

The continuous working of the drill is also found to minimise the risk of "caving," the danger of which is found by experience to be greater during the period of rest.

The speed made by Parker's rotary drill is comparatively so great that the most careful expert observation is necessary in order to ensure that the drill does not penetrate and pass through oil-bearing strata without the oil indications being noticed, and for this reason it is absolutely essential that if this drill is employed it should be in thoroughly experienced hands. I am assured that there is no possibility of the strata being passed without sufficient oil indications being apparent at the surface, provided the men in charge are expert oil borers, but very capable and experienced men are invariably employed with this machine, because it is of paramount importance that they should be always on the alert and capable of interpreting the signs and indications which are only temporarily present, owing to the speed at which the drill travels.

Sir Boverton Redwood suggested that further information should, if possible, be obtained with regard to the rock from which the escape of gas took place. He would like to know if it was of such a porous character as to permit of its being a possible and extensive reservoir for the retention of oil; and for the successful operation of an oil well he regards it as essential that the over-lying rock should be of a solid and impervious formation, like shale, for instance, so that it might, in a sense, be regarded as a lid to the reservoir containing the oil, capable of preventing the escape of oil or gas, or the mischievous intrusion of super-imposed water.[1] He is of opinion that, in order to avoid the local disturbance created by the intrusion of water at the point at which the Roma bore penetrated the gas region, it might be well to make the next bore at a distance of not less than half a mile from the existing bore.

I asked him if he could help us with any suggestions with regard to surface indications, and he said that in the face of some cliff, or in the cutting made by the flow of some river within perhaps a few miles of the proposed bore, some indication might be found of the extent and direction of the corrugation of the subterranean strata.[2] He explained that oil was generally found in corrugated strata, and experience demonstrated that it was best that the bore should pierce the oil-bearing strata about one-third down the side of an "anticlinal structure." Generally the highest portion of the anticlinal structure was occupied by natural gas, very frequently in a condition of great compression. Below the gas came the oil, and not infrequently below the oil, and in what is called the synclines of the formation,

[1] No. X., par. (vi.), p. 63.

[2] No. X., p. 58 *et seq.;* No. XIV., p. 73.

there sometimes exists water in actual contact with the oil. The annexed sketch will perhaps better illustrate the meaning of this paragraph, and upon reference to this sketch it will be seen that if it is possible to locate, from surface indications, the occurrence

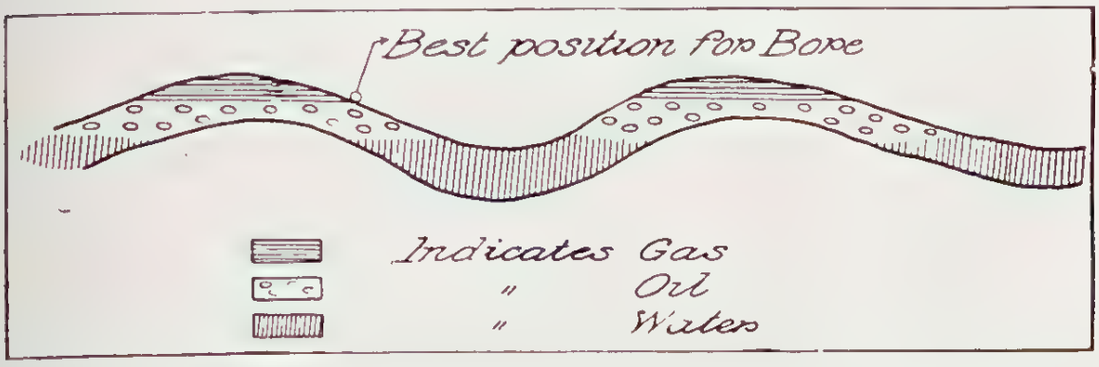

Fig. IX.—Diagram Showing Occurrence of Gas, Oil, and Water.

of this corrugation with sufficient accuracy to permit of a bore being sunk so as to strike an "anticlinal" section, a successful bore would result, while if the bore should unfortunately happen to strike the formation at some portion of a "syncline" occupied by water the bore would be unsuccessful, although in oil country it has sometimes happened that the richer deposit has been missed by a matter of a few feet only.

If you are able to send me any further information of the character suggested by Sir Boverton Redwood, he has been good enough to say he will be pleased to discuss the matter further with me at any time.

I am discussing the question of a bore with the agents for the Parker rotary drill, and will send you some proposal, or, failing that, information as to costs and rate of sinking, &c., as soon as available.

I am, &c.,

(Sgd.) T. B. Robinson, Agent-General.

VIII.—REPORT BY WM. HOPE HENDERSON, M.I.M.M.

Henderson, Henderson, and Higgins,
Mining Engineers,
4, Bishopsgate Street, Within,
London, E.C.,

24th December, 1912.

DEAR SIR,—You were kind enough to ask me to note a few particulars regarding the economic importance of natural gas to which I was referring at our meeting yesterday afternoon, and I have pleasure in doing so, but shall first mention that one of the chief reliable sources from which details are obtainable is the report of the United States Geological Survey Department, as the natural gas industry first became established in that country. I am taking the figures below mentioned from the United States Geological Survey report of 1910 (issued 1911).

The consumption of natural gas in the United States for 1910 was 509,155,309,000 cubic feet, of a value of $70,756,158. These statistics take account only of the gas which was actually used.

The value of the consumption of natural gas in the United States since 1883 is as follows:—

In 1883 the value was	$475,000 —	(£97,500)
In 1893 ,, ,, ,, ...	$14,346,250 —	(£2,948,000)
In 1903 ,, ,, ,, ...	$35,807,860 —	(£7.356,000)
In 1910 ,, ,, ,, ...	$70,756,158 —	(£14,540,000)

Taking three of the most important States—viz., Pennsylvania, West Virginia, and Ohio—the increase in value since 1883 is:—

	1883.	1885.	1905.	1910.
	$	$	$	$
Pennsylvania ...	200,000	4,500,000	19,197,336	21,057,211
West Virginia ...	Nil	40,000	10,075,804	23,816,553
Ohio	Nil	100,000	5,721,462	8,626,954

In 1910 there were in the United States:—

1,327,722 domes ic consumers using 169,823,030,000 cubic f et, of a value of $41,473,903 (£8,520,000).

18,267 industrial consumers using 339,332,279,000 cu' ic feet of a value of $29,282,255, (£6,520,000).

Those official figures speak sufficiently for the status of this

industry, but I may mention that the same report states: "The combined value of the liquid and gaseous fuel product of the United States exceeds that of any other mineral except coal, and is greater than the combined value of all other metals except iron and copper."

Regarding the conveyance by pipe-line of natural gas in the United States, the three following examples may suffice as an indication of how the gas is delivered:—

Cleveland from West Virginia—120 miles of 18-in. and 12-in. pipe with a daily delivery capacity of 83,000,000 cubic feet.

Cincinnati from West Virginia—150 miles of 18-in. and 20-in. pipe with a daily delivery capacity of 70,000,000 cubic feet.

Kansas City from North-East Territory—250 miles of two 16-in. pipes—daily delivery capacity 90,000,000 cubic feet.

All the lines have at intervals a compressing station, with gas-driven pumps, and the gas pressure in the pipes is up to 200 lb. per square inch.

Regarding the production of gas wells, I may say that, although gas wells have been known to yield a flow of upwards of 30,000,000 cubic feet daily, any well which gives 1,000,000 cubic feet a day is considered very good, and wells with a daily flow of 100,000 cubic feet and less are remunerative, depending entirely on the local economic factors which govern the situation.

The pressure existing in gas wells varies between wide margins, but from 200 to 600 lb. to the square inch is quite common.

Natural gas is used principally for light, heat, and power, where its effectiveness in every way is excellent and its far-reaching importance as an industrial agent cannot be disputed. It is unnecessary to instance the enormous growth of numerous industrial centres in the United States due to the discovery of this product.

I should just like to mention that the various States of the United States have of late years taken vigorous steps by passing severe laws regarding the unpardonable enormous waste of natural gas, and this is a subject which should be investigated by any country which is fortunate in discovering such a source of power in large quantity.

I wished to touch on the relationship of natural gas and oil, but I fear I have already extended this memo. to a greater length than was intended. My excuse, however, is that as the subject is a very large one, I find it difficult to condense the information and still give a general idea of the importance of the natural gas industry.

Sir Thomas B. Robinson,
Agent-General for Queensland,
409, 410, Strand, W.C.

IX.—REPORT FROM THE AGENT-GENERAL TO THE CHIEF SECRETARY.

London, 23rd January, 1913.

Sir,—Referring to my letter of 7th instant,[1] with reference to the Roma Bore:—

I have now the honour to enclose, for your information, copies of letters which I have received from Messrs. J. F. Lucey, Gillespie, and Company, the British agents for Parker's rotary drill, copy of a specification and estimate for an equipment as would be required for boring under similar conditions to those which exist on the site of the present bores, and a letter addressed to Parker's representative in New Zealand, which would introduce anyone whom you might appoint to investigate the suitability and success of the Parker method of drilling, and would ensure that every possible information were placed at his disposal.

You will notice on page 10 of the estimate marked "A" the prices of the casing are stated at so much per foot, and in discussing this matter with Mr. Gillespie subsequently I requested him to apply the information disclosed by the description of the strata which occurred in the reports, and estimate exactly what casing would be required and state the cost thereof. This information, which summarises the cost of the suggested outfit, is contained in the papers attached to Messrs. J. F. Lucey, Gillespie, and Company's letter of the 16th January, and the amended page 10 is marked "B."

* * * * *

I am sorry to say that Mr. Gillespie is not willing to make any proposal with regard to undertaking the boring on behalf of the owners of the drill, and he gives as his reason the fact that they have now concentrated all their energies upon the manufacture and supply of the equipment, as the reputation already established ensures them a sufficient succession of orders to keep them fully occupied in every direction.

I am told that if a machine were ordered it would be shipped within four weeks of the receipt of the order in New York.

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[1] No. VII. of this publication.

Two experienced oil drillers must be employed with each machine, and each driller would require three labourers as assistants. These could be recruited locally, and would have to work on alternate shifts with their respective driller.

It is claimed that, exclusive of casing, the cost of drilling should not exceed 7s. 6d. per foot, as against £2 per foot the cost of sinking by means of other drills. An instance was cited of a bore of 1,500 ft. which had been sunk in sixteen days. The contractor had undertaken to do this at 8s. per foot, but his actual cost was known to have been less than 2s. 6d. per foot.

With this apparatus I am assured that a bore of the size named should be easily drilled, through strata such as exists at Roma, at a cost for labour and fuel of less than £1,000. The only additional expense would be for the piping, or casing, which is included in the amended specification marked "B."

The outfit quoted for by Messrs. J. F. Lucey, Gillespie, and Company is capable of drilling at least twenty wells, with the exception of the casing, although, of course, a few spares would be necessary from time to time. Of the casing included in the specification, a very considerable proportion would be available for use in subsequent work, as so much of it as was not actually needed might be withdrawn from the bore after it had served the temporary purpose. If water was not present in large quantities the greater part of the casing could be so withdrawn.

The expert drillers referred to by Messrs. Lucey, Gillespie, and Company would require to be paid a salary at the rate of £600 per annum, their fare to and from Australia, and possibly an allowance for board and lodging. They would ask for a contract of twelve months' work, but while on the voyage to and from Australia half salary only.

Mr. Gillespie estimates that a bore of the size mentioned in his letter (which you will notice is somewhat larger than the size suggested by Sir Boverton Redwood) could be sunk, with the appliances described in the enclosures hereto, in well under three months.

I shall continue my inquiries in connection with this matter in any quarter from which I think we might obtain any further useful information, but I thought it advisable to send these particulars along to you without delay, so that they might be at the disposal of the Government, or any private undertaking, if the Government should decide to give assistance to others rather than undertake the actual boring operations themselves. The

control of such a plant in Queensland might be a profitable possession for those engaged in boring for water, because of its economy and speed, but in searching for oil it is perhaps as well to emphasise the absolute necessity, in the first instance, that the boring machine in question should be under the control of men well experienced in the special business of searching for oil.

During a recent conversation with Mr. Christison, he mentioned to me that natural gas was known to exist in considerable quantities on Glenariffe Station, lately in the occupation of Messrs. Stuart Brothers and McCachie, and next to his Lammermoor Station. In case this fact may not be on record, I thought it well to repeat his statement here.

I have, &c.,

T. B. Robinson, Agent-General.

X.—MEMO. FOR THE UNDER SECRETARY FOR MINES.

By W. E. Cameron, Assistant Government Geologist.

Brisbane, 26th March, 1913.

I have read the letters of the Agent-General of 7th January and 23rd January and the enclosed reports from Dr. Veatch and Mr. Wm. Hope Henderson, and also the proposal of the J. F. Lucey-Gillespie Co. for the supply of a rotary flush drill for prosecuting a further search for oil in the neighbourhood of Roma, and herewith deal with the matters brought up in those reports.

1.—Report of Dr. Veatch.

This report, coming as it does from a geologist with a wide experience of the oilfields of the United States and other parts of the world, is distinctly encouraging as to the possibilities of finding oil near Roma, even though optimistic expressions of opinion have been carefully avoided. Though not directly stated in words, the whole tone of the report appears to me corroborative of the opinion expressed in my memo. of 1st July last, that the character of the Roma gas occurrence is an indication of its having been given off from oil. The opinion expressed in the second paragraph of Dr. Veatch's report—viz., that "While a gas well does not necessarily mean there is oil near by, the finding of gas of this character makes the prospects for oil much more favourable than if no gas had been found"—is to my mind sufficient warrant for hoping for ultimate success if a well-thought-out scheme of boring is adopted and persisted in.

No unfavourable indications have been noted by Dr. Veatch, and the difficulties of dealing with the heavy flows of water and great depths are not regarded as insurmountable, so that there seems no reason why boring should not be hopefully carried out until at least unfavourable indications are noted. Stress is laid on the necessity of having the work supervised by men of experience in oil development if success is to be hoped for.

In the absence of knowledge of the minor details of the local structural conditions, Dr. Veatch's recommendation is that the boring should go deeper. There is no prospect of obtaining further information of value as to the local structural conditions in a country like the Roma district (where geological sections

are conspicuous by their absence) until many more bores have been put down and correct records of the strata passed through have been made and studied. The only reasonable course therefore at present seems to me to go deeper in the neighbourhood of the present bores, in terms of Dr. Veatch's recommendation.

II.—Prospects of the District as a Source of Supply of Natural Gas.

Dr. Veatch's report incidentally draws attention to the probable value of the gas-bearing stratum as a source of supply of cheap fuel and light and for the production of liquid petroleum products, and a thorough testing of the bed seems to be warranted on this account alone, apart from any prospect there may be of getting oil.

Mr. Wm. Hope Henderson's report gives statistics of the natural gas industry in the United States, and indicates the possibilities of such an industry in Queensland if gas can be found in quantity. The report serves to point out what a valuable asset may be lying undeveloped in the Roma district in the form of cheap fuel for manufacturing purposes, and shows that gas can be economically piped for several hundreds of miles to centres of industry.

The fact that at Roma a second bore, sunk only 240 ft. from a bore which had already flowed gas at the rate of from 40,000 to 70,000 cubic feet annually for 4½ years, itself struck a much more violent outburst of gas at about the same depth, seems to me to carry great possibilities for this district in this respect.

III.—Proposal of the J. F. Lucey, Gillespie, Company for the supply of a rotary drill and two expert drillers, and remarks of the Agent-General in relation thereto.

If it is intended by the Government to sink only one bore to test the beds immediately below Roma, the cost under this company's scheme for a depth of 4,000 ft. may be estimated from the company's list of costs of material and the Agent-General's remarks to be somewhat as follows:—

	£
Rotary boring plant and tools	2,390
Casing for bore, starting at 18 in. diameter ...	4,410
Salaries of two expert drillers under one year's engagement at £600 each	1,200
Fares and expenses of same	300
Wages of labourers	300
Fuel	400
	£9.000

As this does not include freight on machinery, cost of derrick and puddler, loss from delays, and probably many other

incidental expenses, it is quite likely that a bore under this system will not be sunk for much under £10,000.

It will be noticed from the Agent-General's letter of 7th January that Sir Boverton Redwood, the petroleum expert consulted by him, gave an opinion that an expenditure of £8,000 to £9,000 at least should be contemplated.[1]

The Roma Mineral Oil Company's bore was drilled by percussion methods to a depth of 3,702 ft., for an expenditure of about £5,000. In this case the machine was supplied by the contractor.

The gas bore has a 6-in. casing to 2,577 ft., and in the oil bore the 6-in. casing was taken to a depth of 3,702 ft., but this casing was subsequently pulled. The present position of the casings in the two bores are shown on the accompanying sectional sketch[2] of the bores, which also give the strata that were passed through. It is quite possible that an expert might advise a further trial at removing the obstacles in these bores so as to test the lower strata at this spot in preference to sinking an entirely new well.

IV.—Efficiency of the Rotary Method of Boring in Prospecting for Oil Beds.

In this connection the Agent-General says in his letter of 7th January: "I am assured that there is no possibility of the strata being passed (with the Parker rotary drill) without sufficient oil indications being apparent at the surface, provided that the men in charge are expert oil borers."

It is not clear from the Agent-General's letter whether this is an opinion of Sir Boverton Redwood or merely the assurance of the company interested in selling the machine, but I am inclined to think the latter, and for the following reason:—

Mr. A. Beeby Thompson, a very well known petroleum expert, in his work entitled "Petroleum Mining and Old Field Development," under "Objections to Flush Drills," page 211, says:—"Rotary flushing systems are not generally favoured for petroleum drilling, as the water sometimes conceals the identity of the beds passed through, and occasionally prevents the admission of oil into the well. . . . In districts where flushing systems are largely used the approximate depths of oil-bearing strata are known, and the occurrence of sand at about the estimated depth is usually sufficient justification for testing the well."

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[1] No. VII., p. 48.

[2] Fig. X. amplified for this publication.

Mr. Thompson then goes on to record that a well, drilled by the hydraulic rotary method at Spindle Top, Texas, passed into a known oil stratum without making any showing of oil at the surface, though the well on being agitated and bailed for six days finally gushed and flowed a solid six-inch stream of oil.

These remarks apply perhaps more particularly to water-flush methods as distinct from mud-flush methods, but, as the context shows that Mr. Thompson was acquainted with the mud-flush system, it is not likely that he would neglect that phase of the question, and in any case it is difficult to see how the introduction of mud instead of water would be any more favourable to a showing of oil on the surface. It is a demonstrated fact that oil will not enter wet clay or rocks, and that wet rocks are the most impervious cap rocks for oil, so that the assertion of Mr. Gillespie, the agent in London for the Parker rotary drill, in his letter to the Agent-General of 14th January, that "it is a physical impossibility to not get a showing of oil with thick mud" must, it seems to me, be taken with a considerable degree of caution, at any rate for cases where the oil does not occur under heavy pressure.

Mr. Thompson's remarks seem to imply that the Parker rotary machine would not be the best machine to use where the presence or otherwise of oil-bearing strata has to be determined for the first time, though it might be a very economical machine where a number of wells have to be drilled to an oil stratum, the position of which is already well known, or where thick beds of "quick" sands have to be passed through.

Another objection urged against the use of flush drills for oil-boring is that they allow water to enter into the oil-beds, so that they become flooded, and productive wells in the neighbourhood become injured. This objection would not perhaps have any great force in regard to a first well where the oil-bed has not been depleted of any oil, and is fully charged with petroleum, and could perhaps be hardly urged against the Parker drill if it could be demonstrated that it afforded a cheaper and more efficient method of prospecting the beds, as under proper supervision the influx of any large quantity of water could probably be provided for.

A third objection to the purchase of a machine of this character is that it requires large supplies of water for its operation, and if it enters very porous strata these quantities may even become enormous until the beds become plugged up

with mud. Its use is therefore precluded in any positions not favoured by a large supply of water, and the machine would therefore be subsequently of little use to the Government.

It is quite possible that Sir Boverton Redwood, in mentioning the Parker drill to the Agent-General, had not at the time gone fully into these points, and it is not clear from the Agent-General's letter of the 7th instant how much of the information there given is the reflection of merely extempore observations of Sir Boverton Redwood, and how much the representations of Mr. Gillespie, acting as agent for the makers of the machine, and naturally anxious to bring about a sale.

V.—Recommendation.

It is impossible to give an opinion on points of this kind without a personal acquaintance with the different methods of boring for oil, but, in view of the published adverse remarks of Mr. Thompson on the suitability of flush-drilling for prospecting new country, it appears to me that the Government would be ill-advised to accept the selling agent's estimate of the value of the Parker rotary machine without first submitting the question to an independent expert conversant with oilfield development. It seems to me therefore that the only manner in which this matter can be effectively handled, if the Government contemplates the necessary expenditure, is that the Agent-General should be instructed to engage an expert as consulting engineer, and be guided solely by his advice. Even if this course necessitates a visit of the expert to Queensland for the purpose of becoming acquainted with the local conditions, or the engagement of an engineer to supervise the work of boring, I am of opinion that the expense will be justified by the importance of having the test bore put down under the most expert supervision. The questions that would have to be determined by such an engineer would include—

(1) The best positions for boring.

(2) The most suitable and economical style of boring and casing considering the local conditions.

(3) The most economical size of bore capable of coping with the depths to be reached.

(4) The best and least expensive methods of effectively sealing off water from the upper beds.

(5) The positions at which boring should be suspended in order to test the strata for oil, and the best methods to use for testing the strata.

(6) The methods to be adopted to deal with the flows of gas and possibly of oil as regards economy and safety; and many other questions that would undoubtedly crop up.

Even if the Parker rotary drill should be deemed suitable and the two drillers mentioned by the Agent-General were sent out to run the machine, it seems to me that it would be necessary to have the work in charge of a competent engineer more directly responsible to the Government as regards the points above mentioned.

VI.—Additional Information.

In his letter of 7th January the Agent-General stated that Sir Boverton Redwood requested further information as to the porosity of the rock in which the gas was struck as indicating the possibilities as a reservoir of oil. I have recently been able to inspect a sample of the grey shale reported by the driller of the Municipal Council's gas bore as existing from 3,579 ft. 6in. to 3,709 ft. 8 in. The rock is a micaceous grey shale, and its character would not indicate the likelihood of its being a very prolific source of oil owing to its want of porosity. It must not be forgotten, however, that fractured shales have before this given commercially valuable supplies of oil,[1] and of course there is every possibility of more porous beds occurring below the depths reached by the present bores.

As regards the solidity and imperviousness of the overlying rocks that might act as a cap rock and prevent the escape of gas and oil, there seems no need for anxiety. I regard the fact that little or no occurrence of gas was met with until the sudden and powerful outburst was met with in the second bore sunk only 240 ft. from the first bore which had been giving off gas for four and a-half years as sufficiently reassuring evidence on this point.

Dr. Veatch inquires as to whether the gas stratum is an artesian water horizon, remarking that this point is not altogether clear from my previous report. I have made further inquiries about this matter, but can come to no more definite conclusion than when I wrote formerly. The driller of the gas bore (the first bore) assures me that the 39,000 gallons per day coming up with the gas in the 5-in. casing in that bore was struck with the gas, but it seems strange that a grey shale of the character found between 3,579 ft. and 3,709 ft. should be able to give a supply of this volume unless there were coarser layers in it that have not been recorded.

Sections of strata.—Recently, through the courtesy of Mr.

[1] The Florence Oilfield, Colorado. Bulletin U.S. Geolog. Survey, No. 381, p. 521 *et seq.*

Schooley, manager for the contractors for the Mineral Oil Company's bore, I have obtained a copy of the driller's journal of the strata met with in that bore, and I have prepared the accompanying section[1] showing the positions of these two bores and the strata passed through, which may be of value to any engineer that the Agent-General may consult. The two journals agree fairly well to a depth of 3,200 ft., but after that they differ considerably, the log of the "oil bore" showing numerous hard bands of "cement" and rock not noted in the "gas bore," and there being considerable disagreement in the colours of the shales. I understand from Mr. Schooley that his driller was instructed to note particularly any hard bands for the purpose of getting a firm seating for the 5-in. casing, and that probably these hard bands are merely more siliceous and harder bands of shale. The discrepancy in the colours of the shales is perhaps due to faulty observations of one or other of the drillers rather than to any real difference in the character of the rocks passed through in the two bores. Without an opportunity of inspecting the corresponding samples in each of the bores. it is impossible to say more on this point, but the fact that gas was struck at practically the same level in the two bores and that they are under one hundred yards apart is corroborative of the above interpretation of the journals of the strata.

VII.—Cementing the Present Bores to Prevent Influx of Water into the Gas Stratum.

Dr. Veatch suggests that, as a precautionary measure to prevent further depreciation of the gas stratum by influx of water from above, the two present bores should be cemented at the bottom. As regards the oil bore, the 6-in. casing has, I am informed, been nearly all pulled, and if the bore has not blocked itself below the seat of the 8-in. casing large quantities of water must be entering the gas zone. It is quite possible that this could be efficiently prevented by plugging the bottom of the bore with clay, or a mixture of clay and sand, which could be easily drilled out if it were subsequently decided to attempt to again remove the tools at the bottom and drill further. As regards the gas bore, the 4-in. casing was broken off at the 3,273-ft. level. It is quite possible that this bore could also be plugged up with a mixture of clay and sand, which would allow of its being reopened if it were decided to use this bore for further testing the lower beds. These are again questions that should be left to the engineer consulted by the Agent-General. The present positions of the casings in the two bores are shown on the accompanying section.[1]

[1] Fig. X. amplified for this issue.

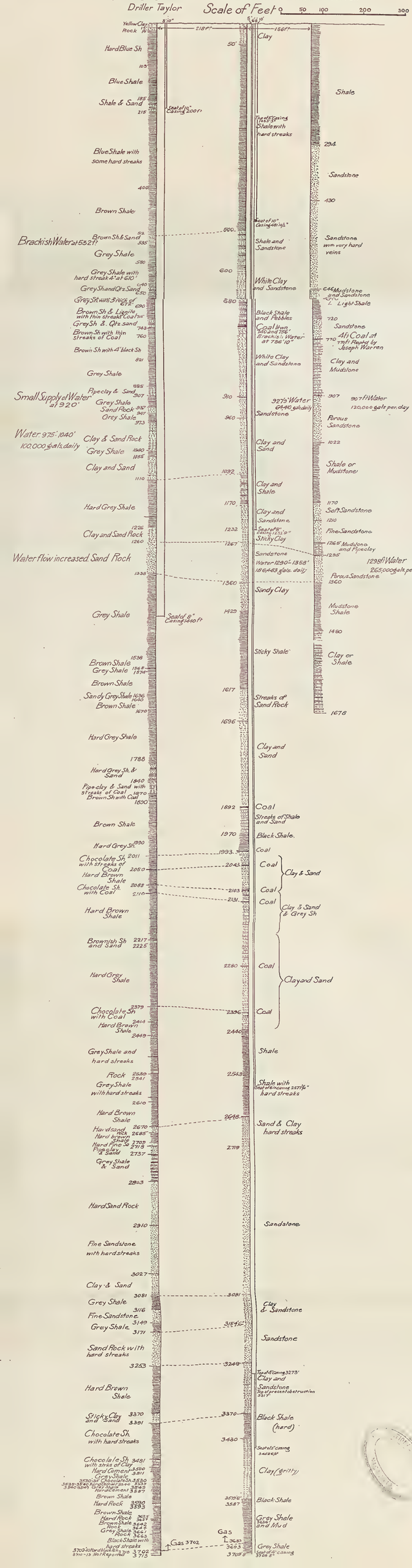
Fig. X. Sections of Strata and Positions of Casings

ROMA BORES

No. 3 Oil Bore — No. 2 Gas Bore — No. 1 Water Bore

Supervising Engineer J. Warren — Driller A. Lamb — Driller J. Warren

Driller Taylor — Scale of Feet 0 50 100 200 300



XI.—MEMO. FOR THE UNDER SECRETARY FOR MINES.

By W. E. Cameron, Assistant Government Geologist.

Brisbane, 9th June, 1913.

(On adverse remarks as to prospects for oil at Roma, by J. E. Carne, Assistant Government Geologist of New South Wales, in "Occurrence of Coal, Petroleum, and Copper in Papua."[1])

I have read the portions of Mr. Carne's "Notes on the Occurrence of Coal, Petroleum, and Copper in Papua," which refer to the occurrence of gas at Roma and the consequent prospects for oil.

Since Mr. Carne has published a clearly defined opinion on these prospects in the above publication, I do not consider that it is necessary to secure his services for a second report on the subject.

Mr. Carne says as follows:—

"Gas springs or gas pools are a common feature of oil regions, but dry gas jets do not always indicate commercial supplies of oil, or even its presence in some cases.

"Turning to Australian instances, the strong outbursts of gas struck in the Grafton (New South Wales) and Roma (Queensland) bores are probably derived from coaly strata encountered in each.

"Whilst it would be unwise to dogmatically assert that oil would not be struck at any depth in these rocks, yet it must be conceded that all known indications are against the possibility. In each case depths of over 3,700 ft. have been drilled without the slightest trace of oil; in each also, gas was encountered in quantity only in coal-bearing strata. Moreover, there is entire absence of the usual geological structure associated with the occurrence of oil in the majority of oilfields. The only disturbance noted in Australia in strata of the geological age of the beds penetrated in the above bores are faults. Folding is conspicuously absent. Though gas doubtless exists in horizontal beds;

[1] Bulletins of the Territory of Papua, No. 1, Department of External Affairs, Melbourne.

still it is only in domes or anticlinal arches that it accumulates in sufficient volume and under sufficient pressure to maintain continuous outflow for lengthy periods.

"In both of the bores mentioned the pressure was insignificant, compared with the terrific force with which petroliferous strata discharge imprisoned gas; the volume likewise was very small when similarly compared. In both instances the gas gave out almost entirely. At the Grafton bore it is now only sufficient to maintain a flame 2 in. long, which can be blown out with the breath.

"Usually, heavy discharges of gas bear with them light oil, or 'spirits' in the form of spray, if arising from oil-bearing strata."

Mr. Carne's opinion is, therefore, distinctly unfavourable to the prospects of finding oil below Roma, this opinion being based on the following five, to his mind, adverse indications:—

(1) No trace of oil being found within 3,700 ft. of the surface;
(2) The gas was encountered in quantity only in coal-bearing strata;
(3) Absence of folding of the beds;
(4) Insignificant pressure of the gas as compared with the terrific force with which petroliferous strata discharge imprisoned gas, and comparative smallness of the volume.
(5) Absence of sprays of light oil or "spirits" with the gas.

While all these conditions were known to Dr. Veatch from my report submitted to him through the Agent-General, he makes no reference to them, so that apparently he was not particularly struck with their adverse bearing on the prospects for oil.

It is unfortunate that these remarks of Mr. Carne were not published in time to be submitted to the Agent-General for Dr. Veatch's consideration[1]; and, although I am not myself so impressed with their adverse bearing on the prospect as to consider that they warrant the abandonment of the proposed testing of the beds, I think that before any further action is taken, these remarks of Mr. Carne should be submitted to Dr. Veatch for his opinion.

If Dr. Veatch is still of the opinion that the prospects are sufficiently promising to warrant the beds being tested there

[1] See No. XII., p. 68.

seems no reason why preparations should be delayed longer, unless the Government would like to get a further opinion on the subject, in which case I would suggest that either Mr. Beeby Thompson or Mr. Cunningham Craig, both of England, and both with a wide experience of oilfield geology and development, might be consulted for a second opinion.

If it is finally decided to further test these beds it will be necessary for the Agent-General, acting on the advice of Sir Boverton Redwood or some other consulting engineer of note, to secure the services of an engineer conversant with the best methods of boring for oil and ready to take charge of the boring operations, and see that they are efficiently carried out, either by contracting for the work or by making use of the machinery already in the Government's hands as he finds most suitable. This engineer would probably have to receive a twelve months' engagement in the first instance, and probably the method of procedure would not be finally decided on until he arrives in Queensland.

XII.—REPORT ON MR. CARNE'S REFERENCES TO OCCURRENCES OF GAS AT ROMA.

(See No. XI.)

By Dr. A. C. Veatch, Consulting Geologist.

About November, 1913.

These papers have just reached me here, and I take pleasure in forwarding the following comments:—

Mr. Cameron is quite correct in stating that all the facts mentioned in Mr. Carne's opinion were made plain in his report, on which I founded my statement.

With Mr. Carne's observation that "Gas springs or gas pools are a common feature of oil regions, but dry gas jets do not *always* indicate commercial supplies of oil or even its presence in some cases," I am heartily in accord.

The broader features of the Queensland situation appear to be the known occurrence of a great thickness of sedimentary beds not greatly disturbed, or markedly folded, with the demonstrated presence in one region at least of some of the hydrocarbons related to petroleum. These facts do not place the region in the category where an oil geologist would say there is no possibility of oil, nor do they appear to me to justify so strong a statement as the one that "it must be conceded that all known indications are against the possibility."

I have frequently found that I could best convey my impression of the possibility of developing commercial oil by stating the conclusion in figures. Taking the data presented, together with a general impression of Queensland geology, I should say that the chances in the region in question are as much as 20 in 100. Where it can be said, after careful examination, that the chances are 75 in 100, or better, I consider the matter a very good business proposition; where the chances are 50 to 75 a fair business proposition; and where between 20 and 50 a doubtful business proposition, but I know of many instances where success has been obtained where the chances appeared no better than 5 in 100.

Speaking generally of the relation of oil deposits to structural conditions, it may be observed that commercial oil has been found in practically every structure known to sedimentary rocks. It

is found in the bottoms of steep synclines, as in certain Colorado and Wyoming areas and portions of California; it is found on the flanks of folds or in beds which, considered locally, show a simple marked dip in one direction, and where the axis of the anticline is not related in any way to the oil deposit, the bulk of the large production of California comes from this type of structure; it is found in beds, flat or gently dipping, which may be considered for most purposes, as unfolded, as in Ohio, Indiana, Illinois, Kansas, and certain Louisiana and Texas fields, as well as the great Mexican fields; it is found in badly faulted regions, essentially in fault-blocks, notably in parts of the Russian fields; and it is found intimately related to the crests of marked anticlinal folds and dome structures, as in certain parts of Pennsylvania and West Virgina, at Beaumont (Texas), at Salt Creek (Wyoming), and in the Buena Vista Hills (California). In the Pennsylvania and West Virginia fields, which for practical purposes may be regarded as the home of the anticlinal statement of the occurrence of oil, careful and refined work, with instrumental control, has shown that most of the pools lie on the flanks of folds, and that it often happens that the location of the pool is determined by some minor irregularity on the side of the fold, and not by the position of the anticlinal axis itself.

Referring to the occurrence of oil in relatively flat structures, I am of the opinion, from a very wide study of sedimentary strata, that it is most unlikely that there exists any extensive area of sedimentary strata, which is usually described as flat or unfolded, in which careful study will not show gentle flexures. This gentle waving of the strata can sometimes be described as folding—one might almost say microscopic folds were it not for the fact that the folds are of great extent, although of no great height. The angles of the slopes of such folds in some fields are so small—the dip being 100 ft. per mile or less—that the rocks would be described under all ordinary conditions as unfolded. The reason for this is evident when it is remembered that a slope of 200 ft. per mile [1] is approximately a dip of 2 degrees, and that owing to several factors a dip of less than 2 degrees cannot be accurately determined with a clinometer such as geologists use.

The structural relations of several important producing oil regions in Illinois will serve to illustrate this point. These oil-pools are situated in a great coal basin—a great synclinal trough whose sides dip so gently that wide studies are necessary to determine the rate. This region, although it had been worked over by many geologists, although coal was worked in it exten-

[1] See No. II., p. 17, for approx. dip of beds at Roma—W.E.C.

sively and simple faults were known in many places, was regarded and described as a simple basin of relatively flat beds affected by minor faults—a description which is quite correct for all ordinary purposes. A geologist trained in minute structural work with precise instrumental control, in the Pennsylvania regions, discovered several very gentle folds in this basin, and indicated that if anyone wished to risk money drilling for oil those were the places at which to drill.[1] The geologist did not and could not state that oil would certainly be found, but the result has nevertheless been the development of several oil-pools now yielding several million barrels of petroleum per year.

A sudden change in the rate of dip along a definite line, even in beds of low dip, is sometimes sufficient to determine the accumulation of oil, yet such a structural feature would seldom be observed or located in ordinary field mapping.

With this rather lengthy explanation of the relation of structural features to oil (particularly in connection with what may for all ordinary purposes be termed as unfolded beds), which is necessary because of the rather prevalent feeling that marked anticlinal or dome features are almost a *sine qua non* in connection with the finding of oil, I add a few comments on the admirable summary by Mr. Cameron of the points which Mr. Carne considers against the possibility of finding oil:—

1. "No trace of oil being found within 3,700 ft. of surface." This statement bears on the cost of drilling and production rather than on the absence of oil—a point which, although my previous memorandum[2] is not here, I think was indicated in it.

2. "The gas was encountered only in coal-bearing strata." Oil is found in coal-bearing series in many parts of the world, as in Trinidad, B.W.I., Wyoming, Illinois.

3. "Insignificant gas pressure." Many wells producing oil commercially by pumping have practically no gas pressure, and gas pockets with low pressure are not uncommon in regions of spouters.

4. "Absence of folding." This I take to mean absence of pronounced folding. Most of the great production in Mexico comes from beds not markedly folded. This is true also in many districts in Ohio, Indiana, Illinois, Kansas, Louisiana, and Texas.

5. "Absence of sprays of light oil or spirits with the gas." Mr. Carne's statement is that "usually *heavy* discharges of gas

[1] Oil Resources of Illinois. Raymond S. Blatchley. Bulletin 16, State Geolog. Survey, 1910, p. 167 *et seq.*—W.E.C.

[2] No. VI., p. 44.

bear with them light oil or 'spirits' in the form of spray," which is very true for the reason that the great pressure is a factor in lifting this spray to the surface. Conversely, light discharges of gas do not commonly bring up a spray of oil, for the also very good reason that the pressure is not sufficient. Mr. Carne makes a special point of the insignificant pressure of the gas.[1]

It should be borne in mind that I am without the advantage of the personal knowledge of the district which Mr. Carne doubtless possesses. I am able, therefore, only to discuss the question from the broad standpoint of oil geology in general.

I should certainly recommend a most minute, careful, instrumentally accurate study of the minor structural features[2] of the district (provided, of course, there was no reason for believing there was discordance in dip in the underlying beds, due to folding erosion[3] and subsequent deposition in this locality at some period anterior to the period represented by the strata outcropping) before determining the site of the test bore, should the Government decide to try the experiment.

[1] No. XI., p. 66.

[2] See No. X., p. 58, at bottom—W.E.C.

[3] See Introductory Note and Fig. X., also No. XIX., p. 86, also p. 32, Note 1—W.E.C.

XIII.—MEMORANDUM RE OIL IN QUEENSLAND.

By P. Charteris A. Stewart, Consulting Geologist.

I have been through the Queensland file, including Dr. Veatch's last opinion, which has now come to hand.

I concur in his conclusions. Without caring to express a definite opinion as to the exact chances of success in this risky undertaking, I do not think the Queensland Government is justified in accepting Mr. Carne's sweeping unfavourable statements as final.

I wish to emphasise Dr. Veatch's opinion on the absolute necessity of a very detailed geological map of a fairly comprehensive area, to show all the comparatively minor geological structure.[1] In order to do this, a really accurately contoured topographical map is necessary for a basis on which to work. The geological survey should be made before one can even discuss whether one is justified in doing any further drilling or not.

I do not know what programme has been outlined for Dr. Wade by the Commonwealth Government, and it may be intended that he, with the assistance of a sufficiently large staff, should carry out such detailed surveys of selected areas, as I have indicated, but there cannot be any doubt that this is most necessary, as in all probability the accumulation or otherwise of the oil may in this instance depend upon comparatively local structure in the rocks, and drilling without having such knowledge first is merely taking a hit or miss chance.

[1] See No. X., p. 58, at bottom.—W.E.C.

XIV.—MEMO. FOR THE UNDER SECRETARY FOR MINES.

By W. E. Cameron, Assistant Government Geologist.

Brisbane, 6th March, 1914.

(*Re* Dr. Veatch's latest opinion on the possibilities of discovering oil at Roma and recommendations for further geological investigation, and also Mr. P. Charteris A. Stewart's corroboration of that opinion and recommendation.)

Dr. Veatch and Mr. Stewart both agree that Mr. Carne's published opinion, which was emphatically adverse to the possibilities of oil at Roma, and was recommended for consideration in my memo. of 9th June last, is not warranted by the phenomena recorded. Dr. Veatch enters very fully into his reasons for disagreeing with Mr. Carne's adverse deductions from these phenomena, and deals with each point made by Mr. Carne seriatim, no doubt in all cases drawing his inferences from oil fields with which he is acquainted either personally or through the official literature dealing with them, and in some cases quoting examples of oil fields already in existence which controvert Mr. Carne's deductions. Dr. Veatch and Mr. Stewart also recommend a detailed geological examination of a fairly comprehensive area, based on an accurately contoured map, with a view of detecting structural features in the rocks which would be favourable to accumulation of petroleum of commercial value.

The topographical survey of the district has been in hand since the middle of December last, and a map of an area of about 14 square miles around Roma, on a scale of 8 chains to an inch, contoured with level and staff by Messrs. Naylor and Eberhardt and showing 10 ft. contours, surface features, and land portions, has been prepared and forwarded to the Government Printer for reproduction. Mr. Naylor is also making a topographical map of an area of about 500 square miles to be produced on a scale of 1 mile to an inch, and the field work for this will be completed shortly.

Dr. Veatch concludes his report thus:—

"I should certainly recommend a most minute, careful, instrumentally accurate study of the minor structural features of the district (provided, of course, there was no reason for

believing there was discordance of dip in the underlying beds, due to folding erosion and subsequent deposition in this locality at some period anterior to the period represented by the strata outcropping) before determining the site of the test bore should the Government decide to try the experiment." Mr. Stewart makes his recommendations in these terms, *i.e.*—" The geological survey should be made before one can even discuss whether one is justified in doing any further drilling or not . . . . as in all probability the accumulation or otherwise of the oil may in this instance depend upon comparatively local structure in the rocks, and drilling without having such a knowledge is merely taking a hit-or-miss chance.' "

Dr. Veatch also quotes the case of Illinois, where gentle folds in a great synclinal trough were determined by such careful geological work and were indicated as being likely places to bore for oil, and where the result has been the development of several oil pools now yielding several million barrels of petroleum a year.

Dr. Veatch mentions that a dip of strata of 100 ft. to a mile is sufficient under some conditions to allow of the migration of oil scattered over a large area into commercially productive pools where a change of dip to horizontal or to an opposite direction has allowed of its being collected and arrested. Slopes as low as 12 ft. to the mile [1] are stated to be capable of this effect where the lightness of the oil and porosity of the strata are sufficiently favourable.

It is extremely doubtful to my mind whether the most careful geological survey of surface exposures would be able to detect such dips even with instrumental control and the most favourable natural exposures of rock; but in the Roma district, where natural exposures are for all practicable purposes non-existent, and there are as yet no data from human operations such as wells, bores, or mines that would be of value for this purpose, except the three bores put down in a confined area on the reserve at Roma, the detection of such structures by further geological work is impossible at present.[2]

In the case cited by Dr. Veatch, where such structures were detected in Illinois and locations for wells determined by them, which subsequently proved very successful in oil production, this was done by correlation of the records of a number of shafts put down for coal-mining purposes, and bores put down in "wild catting" shots for oil, over the length and breadth of a

[1] "Oil Finding," E. H. Cunningham Craig, p. 72.

[2] See No. X., p. 58, at bottom.

well-developed country, where a well-recognised horizon was determined by an easily recognised coal seam. In one section across this country which determined some of these terraces and gentle folds there are as many as 13 bores and shafts to this coal seam in a length of 38 miles, or an average of one every 3 miles.[1]

In the Roma district there is no possibility of getting detailed information of this character without a preliminary boring of the country near the present bores and a particular noting of the depth of one or more well-defined bed or beds. In the bores already put down at Roma there are apparently few well-defined beds at shallow depths to be traced from point to point to give an indication of changes of dip, but seams of lignite were noted by the drillers of all three bores at between 690 ft. and 760 ft., and it is possible that this horizon could be used as an index of any warping of the strata if such exists, by putting down preliminary bores in a line across the country in the line of the general dip—*i.e.*, from north to south or thereabouts at distances of, say, a mile apart.

Such a preliminary boring would add somewhat to the estimate of £9,000 mentioned by Sir Boverton Redwood[2] to the Agent-General as necessary for a test of the beds, and, as it seems to me that these bores would need to be sunk by some form of core drill in order to obtain reliable data, each preliminary bore might cost as much as £400, thus, perhaps, involving an expenditure for six such bores of over £2,400 before any favourable terrace or anticlinal crest could be located. It might even then be found that no such structure exists under Roma, in which case I am aware of no other indication which would serve as a guide for the position of a deep test bore, and the only thing then to be done would, it seems to me, be to put the deep test bore down in close proximity to those that have already struck gas, with the object of testing the beds containing that gas and those below for oil.

Nearly all oil field geologists, however, and among them all those consulted by the Agent-General, lay such stress on the importance of terraces and gentle folds on the prospects for oil, in certain types of oil fields, that it seems to me that some attempt should be made to locate such structures by preliminary boring before plunging into the expense of sinking a deep test bore to 4,000 ft. or more.

[1] Bull. Ill. Geolog. Survey, No. 16, p. 66, and Plate 7, "Oil Resources of Illinois," &c., by R. S. Blatchley.

[1] No. VII., p. 48.

It is very probable that this preliminary boring could be done cheaper than for the figure mentioned above, but this figure is based on contracts already let by the Government for diamond drill boring in this class of country, this form of boring being the only class of core drilling that has as yet been used in Queensland.

As far as I am aware, in no oil field in the world has a systematic attempt to fix likely sites for oil accumulation been made by preliminary boring to determine the disposition of the strata, as regards terrace structures or crests of gentle folds. In the majority of cases I believe I am right in saying that trial bores have been sunk by oil operators furnished often with abundant capital, on the hit-or-miss method, or want of method, condemned by Mr. Stewart in his report, without any regard to the geological structure of the country, and often with a very large number of failures. In some few more recent cases, especially in those countries exploited by English capital, such as Burmah and Persia, geological investigation has been availed of in picking sites for wells, but in these cases the contours of the surface, the coherent character of the rocks, and the comparative steepness of the folding of the rocks have provided abundant exposures by which these structures could be worked out. The method of procedure indicated above will therefore probably be a new departure as regards oil field exploitation, but it may be none the less expedient on that account.

The Roma district differs from most of the as yet proved oil fields in that it has afforded no indication of the presence of oil above a depth of 3,702 ft. from the surface, and that any test bores to prove the beds must probably be sunk to at least that depth before they have any reasonable hope of proving the occurrence or otherwise of oil. It must also be remembered that the terrace and anticlinal theory of the formation of oil pools has only been developed after years of detailed study in America, has only recently emerged from the controversial phase, is applicable only to a minority of varying types of oilfields, and that there has not as yet been much opportunity to test its efficacy for economising expenditure in oil prospecting by means of test drilling such as that recommended above.

It seems to me, therefore, that neither the novelty of the method proposed (if it is novel) for picking likely sites before sinking deep test bores, nor the additional expense entailed by it, are valid objections to its expediency in the case of Roma, if the Government decides on an exhaustive test of the district for oil, but, as I presume that the engineer to be selected for the super-

vising of the boring operations will have also an expert knowledge of oil field geology, it will probably be considered advisable to submit the scheme of work proposed above for his approval or submit it also to Dr. Veatch for his consideration before initiating the work.

A further consideration which will add to the usefulness of these preliminary bores is the fact that by them the prospects for coal under Roma, at the depths above mentioned, will be tested at the same time. I have already recorded in a previous report[1] on coal in the neighbourhood of Roma that a 4-ft. seam of coal was reported by the driller of the No. 1 Artesian Bore at a depth of 750 ft.[2] As this boring was done by cable drilling the information is not reliable, but it is quite possible that a few core drills may disclose the existence of a workable seam in this locality which may be useful for the supply of locomotives on the Great Western Railway system.

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[1] "Queensland Government Mining Journal," Oct., 1913, p. 531.

[2] See Fig. X., Sections of Strata.

XV.—MEMO. FOR THE UNDER SECRETARY FOR MINES.

By W. E. Cameron.

Brisbane, 24th March, 1914.

(*Re* proposed preliminary boring at Roma.)

Dr. Veatch, in his second memorandum forwarded with the Agent-General's letter of 16th January, evidently considers that Mr. Carne's adverse opinion on the prospects for oil at Roma is not warranted by the phenomena observed. Presumably, therefore, the Government will consider the prospects sufficiently promising to warrant their carrying out their original intention of sinking a deep bore or bores near Roma to test the strata for oil. The next step, therefore, is to decide on a position for the first test bore.

Dr. Veatch recommends a minute, careful, instrumentally accurate study of the minor structural features of the district before determining the site of the test bore.

In my memorandum of 6th March[1] I pointed out that, owing to the low contours of the country and absence of exposures around Roma, it will be impossible to get the information desired by Dr. Veatch by a merely surface examination, and recommended a series of preliminary bores for the purpose of elucidating the minor structural features of the rocks, such as broad anticlines (reversals of dips) or terraces (dips abnormal to the general dip), which would aid in fixing the most promising position for the first test bore.

The Honourable the Premier asks the Honourable the Minister for Mines as to the wisdom of spending £2,400 on this preliminary boring work.

From the geological information available at present, it appears that the beds which crop out some miles north of Roma, consisting of alternating sandstones and shales of the Trias-Jura system, have a general dip to the south at a grade of about 150 ft. to the mile, as judged by the positions of their outcrops and in the bores already sunk at Roma.

[1] No. XIV., p. 74.

The position of these beds in the three bores at Roma, although the information has evidently not been accurately recorded, indicate the probability that the beds under Roma itself are in a nearly horizontal position.

It is conceivable, therefore, that a line of six (or less) shallow bores (750 ft. or so) sunk to the north and south of Roma may show that Roma itself is on a terrace with dipping strata to the south, or on the crest of a broad anticline, and would give details of such structures, and may thus be of great value in fixing on the most likely site for sinking a deep test bore.

The question then arises whether this preliminary boring to elucidate structures should be commenced at once or should await the arrival of the expert who is to take charge of the boring, and who will presumably also be commissioned to fix on a site for the first test bore.

The advantages of commencing this preliminary boring at once would be that a considerable amount of additional information will be ready for the expert directly he arrives in Queensland, and thus time will be saved.

As against this will be the consideration that the expert, in choosing a site for a deep bore, may conceivably prefer to have these preliminary bores put down according to his own plan, to give him the information best suited for locating the position of the test bore according to his own ideas drawn from his wider experience.

In addition to this, the expert will presumably be acquainted with the most efficient methods of carrying out this preliminary boring, and may possibly, by the exercise of his engineering experience, save one-third or even half of the estimated cost of £2,400 for these bores, based on diamond-drilling methods in vogue in Queensland.

It may, therefore, be considered better to await the arrival of the expert, if that is expected shortly.

At the same time, the detailed geological examination of the surrounding country asked for by Dr. Veatch should be made as soon as possible, so that that information at least will be available for the expert when he arrives in Queensland.

XVI.—REPORT BY W. H. DALTON, F.G.S., F.C.S.,

CONSULTING GEOLOGIST.

85 Hayter road, Bruxton Hill, London S.W.,
29th April, 1914.

Gas and Oil at Roma, Queensland.

DEAR SIR BOVERTON,—I have duly studied the geological and other documents which you placed in my hands, and whilst assenting to most of the positions laid down so succinctly and lucidly by the several writers, I find points upon which I must dissent from each in turn, and which tend to invalidate to some extent the deductions upon which their advice is based.

Mr. Carne is incorrect in stating that the gas was encountered in coal-bearing rocks, as the borings had passed out of the Jura-Trias series several hundred feet before the gas was reached in the Permo-Carboniferous.[1] In denying any folding of the strata, he asserts what no one knows, the structure being wholly concealed by the overlying Jura-Trias, and the Cretaceous above that. The pressure of gas, which he decries as too scanty to merit much notice, sufficed to hinder operations, despite cavings and lost tools choking the bottom of the bores, and its character is distinctly that of an oil-gas, such as is evolved in most oilfields from natural vents with or without passage through water-bearing beds, to produce "mud-volcanoes" at their exit.

Mr. Cameron seems to be better acquainted with the literature of the subject than with the relative status[2] of the writers he relies upon, and in some measure to confound the distinct professions of engineer and geologist. Co-operation, and not combination, of faculties trained in these widely different functions is the desideratum. The anticlinal theory, so tersely but adequately presented by the Agent-General in his letter to the Chief Secretary of 7th January, 1913, includes that of terrace-structure as a special form of anticline; it never really had a controversial phase, being only a generalising of the self-evident fact that gas, oil, and water, being of different gravities, will separate when not in motion, and that the lighter fluids will be trapped and collected in parts of the strata adapted by structure to such detention, whether by original deposition or by subsequent move-

[1] See "Introductory Note" by the Government Geologist.—W.E.C.

[2] This probably refers to Mr. Cameron's assumption in the second last paragraph of No. XV. that "the engineer to be selected for the supervising of the boring operations will have also an expert knowledge of oilfield geology."—W.E.C.

ments. Certainly, in the majority of known oilfields, the requisite structure is the consequence of flexure, assisted in a minor degree by the lenticular form which is common to all sand deposits as a condition of the process of their accumulation.

Dr. Veatch, with his wide experience of fields where the productive series constitutes the surface, and where the structure is written broad on the face of the landscape, seems to forget that entirely different conditions obtain at Roma, and that whilst, to a duly-trained geologist, the rarity, or even the complete absence, of exposures of the strata does not preclude correct reading of the structure (except where wide areas are covered by superficial deposits, as distinguished from a draping of decomposed rock still in its native place),[1] yet, under the circumstances, no surface survey, as proposed by himself and Mr. Stewart, can be of much utility in solving the question of the occurrence of oil, believed upon satisfactory evidence to be present, not in the Cretaceous system constituting the surface, nor in the subjacent Jura-Trias, but in the still lower Permo-Carboniferous system.[2]

In the two vast breaks in geological time this indicated, no very serious differential movements may have occurred in the region we are considering, but, on the other hand, it is most improbable that the causes of non-existence of strata representing those intervals did not include elevation above sea-level and resubmergence, movements in the last degree unlikely to have been so absolutely regular as to have no tilting or compressive effect on the beds previously deposited, and so to leave the older and subsequent series perfectly parallel. There may exist, beneath the mask of the two newer groups, over 3,000 ft. in thickness, a series of flexures or fractures of the Permo-Carboniferous rocks, of the greatest importance as effecting the concentration or dispersal of any fluid hydrocarbons, oil, or gas, formed in them during their original deposition. That some such products were formed is evidenced by the gas discharged from the borings at Roma, palpably oil-gas.

The store of such gas, and of the oil which doubtless evolves it, cannot be gauged by the duration of its flow past cavings and lost tools under heavy water pressure (over 12 cwt. per square inch).

A series of trial borings of the shallow depth proposed by Mr. Cameron would prove only the structure of the Cretaceous rocks

[1] I do not think this remark will be accepted without question by anyone acquainted with the district under discussion, even though that area is only covered by a draping of decomposed rock.—W.E.C.

[2] See "Introductory Note" by the Government Geologist.—W.E.C.

(which should be determinable by surface study)[1]; it would not decide even the position of the Jura-Trias coal seams,[2] still less that of the Permo-Carboniferous gas and oil. The study of the latter group, where it emerges from beneath the Mesozoic cover, and of the Jura-Trias at the margin of the Cretaceous series, might indicate the degree to which the older group in each case had been displaced or eroded (probably both) prior to the deposition of the overlying series, but even this would be at too great distance from Roma to have any but an indirect and inconclusive bearing on the subject of this inquiry.

The existing records do not seem to indicate any bed in the Permo-Carboniferous portion recognisable without doubt in both wells, and yet, until deep borings establish the position of some such bed over a considerable area, we are, and must remain, wholly in the dark as to the extremely important question of the structure of the gas-producing strata, not only their original composition, the relative proportion and character of sandstones and other porous members, but the flexuring and fracturing to which they have been subjected in the repeated elevations and subsidences of the region. To determine the plane of dip with accuracy, some recognisable horizon must be found at at least four points sufficiently distant to minimise minor inequalities in the original deposition. Three points will determine a plane, but if there is any flexure within the area of the triangle, the calculated plane will not be true. In the absence of flexure, any three of four points will give approximately the same plane; with more discrepant results, flexure or faulting would be legitimately presumable, and a fifth, intermediate hole might be necessary to determine the trend, &c., of the disturbance. Determination of the dip in the boreholes, possible in the case of well stratified rock, are decisive only for the immediate vicinity, although more likely to be of regional extent if of high angle, as gentle dips continually vary in amount and directions, even without flexure of importance.

It would certainly be most unsafe to assume the point of gas-discharge in the two wells as indicating the presence of the same horizon, and even on this hypothesis we should have but two points, not determining any plane. Nor can we assume that the Permo-Carboniferous strata are parallel to the base of the thick

[1] It was stated in my Memos., No. X., p. 58, and No. XIV., p. 74, that it would be impossible to detect structures that might be favourable to oil accumulation under Roma by means of the scanty exposures available.—W.E.C.

[2] The proposition was that the coals reported between 700 ft. and 800 ft. would be also tested by the series of shallow bores proposed. No. XIV., p. 75.—W.E.C.

sandstone, 3,065 ft. to 3,081 ft. deep,[1] as that seems to lie on an irregular (water-worn?) floor of Permo-Carboniferous rocks, for its upper surface shows a descent in the opposite direction—

Gas Bore.	224-feet interval.	Oil Bore.
2,790		2,718
3,065		3,081

In short, we know nothing whatever of the attitude or "lie" of the gas-bearing rocks, and the discrepancy of description thereof in the two borings may result, not from divergence of opinion of the respective drillers, but from each having encountered a different part of this deep-lying series, in consequence of faulting or high dip intervening between the sites, the latter cause conceivably contributing to mishaps in drilling.

If the importance of a possible yield of gas or oil is held to justify a series of trial borings, over 3,200 ft. in every case (with the collateral effect of proving the entire thickness of the coal-bearing beds), the selection of sites for such tests would involve the following geological (as distinguished from engineering) considerations) :—Boring too near the partially exhausted store of gas might strike an impoverished or flooded point of the otherwise productive stratum, and though furnishing important stratigraphical data, would be discouraging from a commercial standpoint. Boring in line with the previous holes will not give the requisite triangle to determine the plane of any bed recognised as reached in the old borings. Boring too far away might, if flexures are present, give a misleading triangulation.

In any case, the selection of each site should be partly dependent on the results obtained by previous operations; whilst the geological study of such results would indicate the direction and approximate distance of each new site, the actual spots would be chosen in accordance with engineering facilities.

Sir Boverton Redwood, 4 Bishopsgate street, E.C.

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[1] Mr. Dalton has taken these figures from my report of 19th Sept., 1911 (No. IV., p. 31 in this issue), they being the only ones at that time available; the Gas Bore and Oil Bore have, however, been transposed. In my Memo. of 26th March, 1913 (No. X., p. 63 in this issue), a full section of the strata in these two bores was given (amplified to Fig. X. of this issue by inclusion of the No. 1 Bore). The thick sandstone may be read in Fig. X. alternatively thus:—

	Gas Bore.	Oil Bore. (1) or (2).
Sandstone	{ 2,709 ..	2,719 2,803
	{ 3,081 ..	3,081 3,027

Judging by the rest of the record, the first of these readings seems the more reasonable, one driller reporting some grey shale and clay and sand where the other reports all sandstone. As thus figured, it does not give any evidence of a waterworn surface or of the bores having passed into unconformably underlying Permo-Carboniferous beds. This section of strata was either not referred to Mr. Dalton or was not noticed by him. Possibly it would modify his opinion as to the gas zone being unconformable with the overlying rocks.—W.E.C.

XVII.—LETTER FROM SIR BOVERTON REDWOOD TO THE AGENT-GENERAL.

4 Bishopsgate, London, E.C.,
30th April, 1914.

Sir,—The report by Mr. Cameron,[1] dated 6th March, which you have placed in my hands since the interview which I had with the Premier and yourself, gives an entirely new aspect to the matter, and in these circumstances I have thought it best to entrust the whole of the available evidence to my colleague, Mr. W. H. Dalton, who, since his retirement from the Geological Survey of this country many years ago, has been actively associated with me in the geological study of petroliferous territories in many parts of the world, and has thus acquired large experience in dealing with such problems as that with which we are presented in regard to Queensland.

I send you herewith Mr. Dalton's report,[2] from which you will see that in his opinion no conclusive evidence as to the existence in the locality in question of petroleum in commercial quantity can be obtained without the drilling of deep test-wells. You will further see that Mr. Dalton regards the indications already met with as distinctly promising.

It appears to me that Mr. Dalton's views are thoroughly sound, and I accordingly concur in them.

Having regard to the great industrial importance which would attach to the development of a source of petroleum in Queensland, I think it would be regrettable if the deep drilling recommended by Mr. Dalton were not carried out, and I trust that it may be found possible to provide the money necessary for such a test, as I consider that the expenditure is fully justifiable, especially as the coal-bearing beds would at the same time be tested.

I have, &c.,

(Sgd.) Boverton Redwood.

Sir Thomas Robinson,
Agent-General for Queensland, London.

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[1] No. XIV., p. 73. [2] No. XVI., p. 80.

XVIII.—LETTER FROM SIR BOVERTON REDWOOD TO THE AGENT-GENERAL.

4 Bishopsgate, E.C., 13th May, 1914.

Sir,—The letter from the Acting Chief Secretary, with enclosures, received with your letter of the 11th instant, affords support to the recommendation that the area should be tested by boring.

In accordance with the request conveyed by your letter of the 7th instant, I have given consideration to the questions of the system of boring to be adopted, and the diameter of the bore holes.

I am of opinion that the diamond-boring system should be employed, and that provisions should be made for obtaining cores of not less than 2 in. in diameter to the full depth. What initial diameter of borehole this will necessitate will depend upon whether the bores are only to be carried to the moderate depth suggested by the Assistant Government Geologist,[1] or are to be extended to a greater depth.

I have, &c.,

(Sgd.) Boverton Redwood.

Sir Thomas Robinson, K.C.M.G.

[1] No. XIV., p. 75.

XIX.—MEMO. FOR THE UNDER SECRETARY FOR MINES.

By Lionel C. Ball, B.A., B.E., Assistant Government Geologist.

Brisbane, 29th June, 1914.

(*Re* Boring for oil at Roma.)

Under your instructions I have perused Sir Boverton Redwood's letters of 30th April and 13th May, and also the report of Mr. W. H. Dalton,[1] sent under separate cover of that letter. I beg to submit herewith my opinion as to the effect of the same on the general question of boring at Roma.

First of all it is necessary to draw attention to Sir Boverton Redwood's statement in his letters of 13th May "that provision should be made for obtaining cores of not less than 2 in. in diameter to the full depth," this being altogether at variance with Sir T. B. Robinson's report of 7th January, 1913, page 3,[2] wherein a diameter of at least 10 in. at 3,000 ft. depth is insisted on.

For ease of reference I propose to take Mr. Dalton's paragraphs seriatim.

Paragraph 1.—Introductory.

Paragraph 2.—This is a refutation of Mr. Carne's adverse statements regarding the possibility of oil occurring below Roma.[3] It is gratifying that Mr. Dalton regards the character of the Roma gas as distinctly that of an oil-gas, such as is evolved in most oil-fields from natural vents.

It is not plain on whose authority or on what evidence (beyond the superficial want of agreement of the two logs below 3,100 ft.) the statement is made that the gas was encountered several hundred feet below the Trias-Jura. For all we know to the contrary, the bores may be still in the Trias-Jura, or even the Cretaceous.[4] This is a point of the utmost importance, for in the latter cases Mr. Cameron's proposed shallow bores might suffice to elucidate the stratigraphy of the gas and oil bearing country. It may be that the presence of the Trias-Jura has been inferred from the coal seams cut in the bores; but the possibility of the Roma coals belonging to the Cretaceous must not be over-

[1] No. XVI., p. 80.
[2] No. VII., p. 48.
[3] Quoted in No. XI., p. 65.
[4] See Note 1, p. 83.

looked, since the Government Geologist has lately decided that the Burrum coals (hitherto bracketed with those of Ipswich in the Trias-Jura) are of Cretaceous age.

Paragraph 3.—With regard to the anticlinal theory ever having had a controversial aspect, I think Mr. Cameron will have no difficulty in quoting chapter and verse in support of his statement. Mr. Dalton's high-sounding generalisations do not appeal to me as in any way invalidating Mr. Cameron's arguments or throwing any light on the actual practice of boring in search of an oil pool at Roma; but it is apparent that the complexity of the proposition, as long recognised by Mr. Cameron, is beginning to make itself felt generally.

Paragraph 4.—Mr. Dalton may have some grounds for his assertion that no surface survey, such as proposed by Dr. Veatch and Mr. Stewart, can be of much utility in solving the question of the occurrence of oil at a great depth, if the oil-bearing strata *do* belong to an older system than those outcropping; but to my mind Mr. Dalton is not warranted in apportioning the strata pierced by the Roma bores to the Cretaceous, Trias-Jura, and Permo-Carboniferous, or even, as shown above, to two systems. If the strata date from one geological period their general conformity among themselves may be anticipated; and from the disposition of the beds near the surface we may deduce approximately that of the deeper seated strata; but, on the other hand, there is bound to be some want of parallelism of the beds, if only that due to lenticularity, and, as this may have been effective in controlling the accumulation of the oil, the balance seems to me to be in favour of deep boring.

Paragraph 5.—Provided that there are breaks or unconformities, Mr. Dalton's inferences cannot be cavilled at—that the structure of the gas-bearing strata may differ widely from that of those nearer the surface. Hence the need for deep boring.

Paragraph 6.—Mr. Dalton plainly regards the gas as being under fairly high pressure.

Paragraph 7.—Mr. Cameron has already demonstrated the impossibility of determining the structure of the Cretaceous rocks (of the upper parts of the bores) by surface study in the vicinity of Roma;[1] and, to overcome in the least costly way the difficulty presented, he suggested shallow boring over a wide area. In so doing, presumably, he regarded the logs of the Roma bores as sufficiently concordant to warrant his neglecting the possibility of unconformabilities at greater depths.[2] Against this

[1] No. X., p. 58, at bottom, and No. XIV., p. 74.

[2] Fig. X., Sections of Strata.

Mr. Dalton considers the risk too great, and hence his insistence on deep boring.

Paragraph 8.—If the presence in the bores of Permo-Carboniferous, besides Trias-Jura and Cretaceous, strata is not denied, Mr. Dalton's contention as to the need of deep boring cannot be gainsaid. The structure of the gas-producing member or members can, of course, be determined with certainty only by deep boring.

Paragraph 9.—Mr. Dalton's presentation of the case for four boreholes in preference to three is not particularly convincing, as, if care be exercised in the examination of the cores (to obtain the angles of dip), three holes would afford all the data required for the detection of faulting.

Paragraph 10.—Here Mr. Dalton definitely places the base of the Trias-Jura at 3,081 ft. in the Municipal bore and 3,065 ft. in the Company's bore;[1] and, because of the very slight differences in the logs below this, refuses to correlate the subjacent strata. Mr. Cameron has explained how the differences may have come about;[2] and, in the records as plotted,[3] I can see nothing against the supposition that the lowermost beds are gently dipping and completely conformable with the superimposed strata. The different thicknesses of the same beds in the two bores may be explained partly by their lenticular form and partly by want of care on the part of the drillers in observing and noting the change from one rock to another.

Paragraph 11.—The theory, that the slight discrepancy in the driller logs towards the bottom of the bores is due to faulting, appears to me to be far-fetched, considering that gas was met in the new bore at the correct depth as calculated from the old. For the same reason, the dip is probably low. If high dips be the cause of the want of concord below 3,100 ft. in the bore records, the position is serious, for, in order to secure definite knowledge as to the dip of the gas-bearing bed or beds, it will be necessary to sink deep bores much less than 240 ft. apart, this being the interval between the present bores.

Paragraph 12.—The economic need of testing the coal seams below Roma to a depth of 3,000 ft. is not yet pressing, and in any case it is unlikely that satisfactory cores of the coal seams will be obtainable in boring for oil. On the other hand, the general consensus of opinion favours the expediency of boring in search of gas or oil. With regard to the location of the bore-

[1] See Note 2, p. 32, and Note 1, p. 83.
[2] No. X., p. 63, Sections of Strata.
[3] Fig. X.

holes, it cannot be denied that boring "too near" and "too far away" will give respectively commercially discouraging and possibly misleading results; but until the bores have been sunk it will be risky to say what is too near or what too far away. Mr. Dalton does not commit himself, beyond advising against a line of bores.

Paragraph 13.—On the whole, much is left to the man on the spot; and Mr. Dalton makes no recommendation as to the site of even the first bore. Notwithstanding this, his report is of value in tending to focus attention on the possibility of there being unconformities above the gas-bearing stratum at Roma;[1] and, though several of the premises on which Mr. Dalton bases his arguments may be denied, the possibility still remains and may not be ignored without grave risk.

Conclusion.

After my perusal of the various reports, I am of opinion that a strong case can be made out for the sinking of one deep bore near those at Roma, rather than of several shallow ones. This, I feel assured, would have been the final decision of Mr. Cameron had not the issue been clouded by the want of knowledge of local conditions of the various experts whose advice has been sought.

The suggested deep bore in producing a core would give a fairly complete and trustworthy section of the strata below Roma; it might throw light on the important question of the ages of the strata; and it might strike oil or, alternatively, it would be almost certain to tap gas, that is, if triangulated with the present bores and to the dip thereof. In the latter event the engineers in charge would be prepared and a direct profit should result for the commercial utilisation of the gas. Moreover, the striking of gas in the deep bore should bring about an important reduction in the cost of power for all future drilling.

[1] No. XVI., p. 81.

XX.—MEMO. FOR THE UNDER SECRETARY FOR MINES.

By W. E. Cameron.

Brisbane, 20th July, 1914.

I have read the recommendations of Sir Boverton Redwood and Mr. W. H. Dalton contained in their reports, forwarded with the Agent-General's letter of 14th May last.

The Government has now a more or less definite recommendation from Sir Boverton Redwood as to the methods that should be adopted to prospect the beds beneath Roma for oil—definite, that is to say, as to the type of boring best suited for the work and the size of hole to be stipulated for, though there is no recommendation as to the position to be chosen for the first test bore.

The scheme of choosing the position for the first test bore by a study of the geological structures of the surface rocks as was recommended by Dr. Veatch[1] and Mr. P. Charteris A. Stewart has been abandoned on the recommendation of Mr. Dalton, on the grounds that the surface rocks will give no indication of the lie of the gas-bearing rocks;[2] and the proposal to sink the first deep test bore by means of a Parker rotary drill has been superseded by a recommendation to use a diamond drill to reach the beds below the gas zone at 3,700 ft.[3]

Such a bore will bring up a core of the strata and presumably the object is to gradually disclose the structure of the gas-bearing and underlying beds by sinking several diamond drill bores if the first two or three bores fail to locate oil, but give prospects sufficiently promising to warrant further attempts.

Sir Boverton Redwood's recommendation is for a core of not less than 2 in. diameter to the full depth, say, 4,000 ft., *i.e.*, to about 300 ft. below the gas zone. The Goldfields Diamond Drilling Company report that they have a machine capable of giving a 2-in. core to 2,000 ft. and a $1\frac{3}{8}$-in. core to 4,000 ft., but that they have no machine in Australia capable of giving a 2-in. core

[1] No. XII., p. 71, and No. XIII., p. 72.
[2] No. XVI., p. 81 *et seq.*
[3] No. XVIII., p. 85.

at 4,000 ft., and that it would cost £2,000 to bring a machine to Australia capable of doing the work as specified by Sir Boverton Redwood.

Before the boring is initiated, therefore, it will be necessary to arrange this matter, and, in any case, it seems to me that it is absolutely necessary that the Government should place the drawing up of the contract specifications and the supervision of the work in the hands of a competent engineer who will make provision for the protection of the bores from influx of water, heavy incursions of gas, and caving strata, will see that the beds are properly tested if indications of oil are met with, and make any other arrangements that he may consider necessary.

By Authority : Anthony James Cumming, Government Printer, Brisbane.

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Plan of Roma Showing Position of Bores.

Scale 10 chains to an inch. Contours from Sea Level.

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Queensland.

DEPARTMENT OF MINES.

GEOLOGICAL SURVEY OF QUEENSLAND.

(B. Dunstan, Government Geologist.)

Publication No. 248.

The Wolfram, Molybdenite, and Bismuth Mines

OF

BAMFORD,

North Queensland.

BY

LIONEL C. BALL, B.E.,

ASSISTANT GOVERNMENT GEOLOGIST.

BRISBANE:

BY AUTHORITY ANTHONY JAMES CUMMING, GOVERNMENT PRINTER.

1915.

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GEOLOGICAL MAP
of
WOLFRAM MOLYBDENITE BISMUTH MINES
at
BAMFORD
NORTH QUEENSLAND

By
Lionel C. Ball B.E.
Assistant Government Geologist

Scale of Chains

0 5 10 15 20

RAISED ON LEASE — LINES & P.O. MARKERS DRAWN BY D. FOX

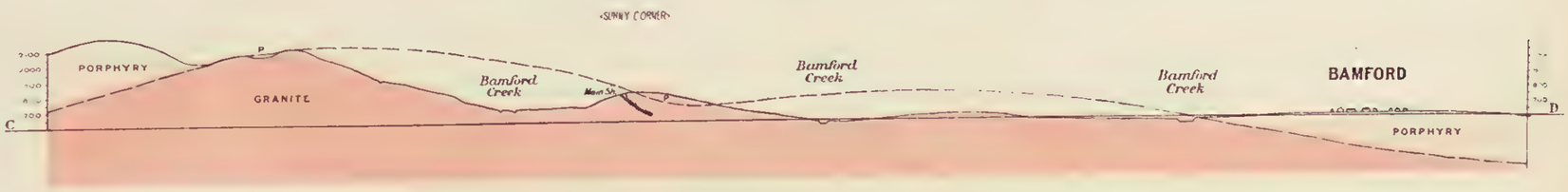
REFERENCE

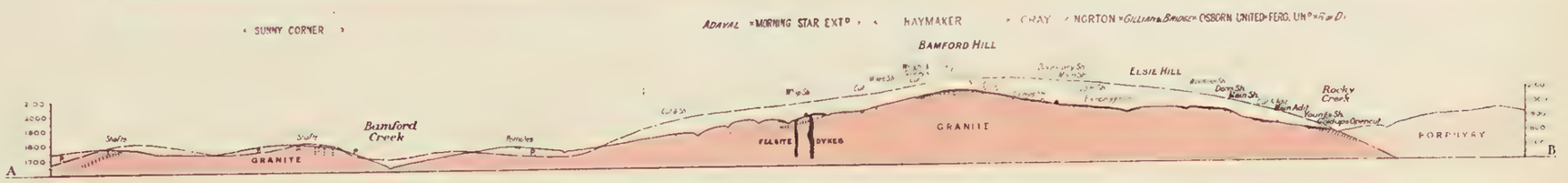
Granite	G	Surfacing	
Greisen	Gr	Potholes	
Molybdenite	Mo	Shafts	
Wolfram	W	Houses	
Bismuth	Bi	Creeks	
Contours (sketched)			

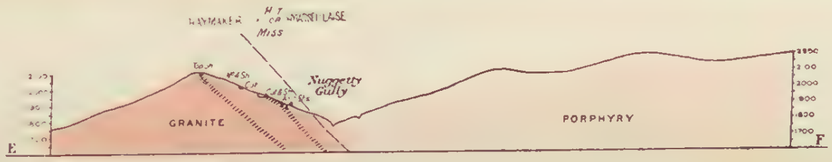
Leases HAYMAKER
Claims HEART

PORPHYRY
Creek
Rocky
GRANITE
Much coarse shoad wolfram won from these gullies
BAMFORD HILL
HAYMAKER
NORTON
Section Line
Nuggetty Gully
Bismuth Gully
PORPHYRY
GRANITE
YOUNG
SUNNY CORNER
PORPHYRY
Section Line
GRANITE
PORPHYRY
Recreation Ground
Creek
TOWNSHIP OF BAMFORD
Bamford
School Reserve

VERTICAL SECTIONS







The Wolfram, Molybdenite, and Bismuth Mines

OF

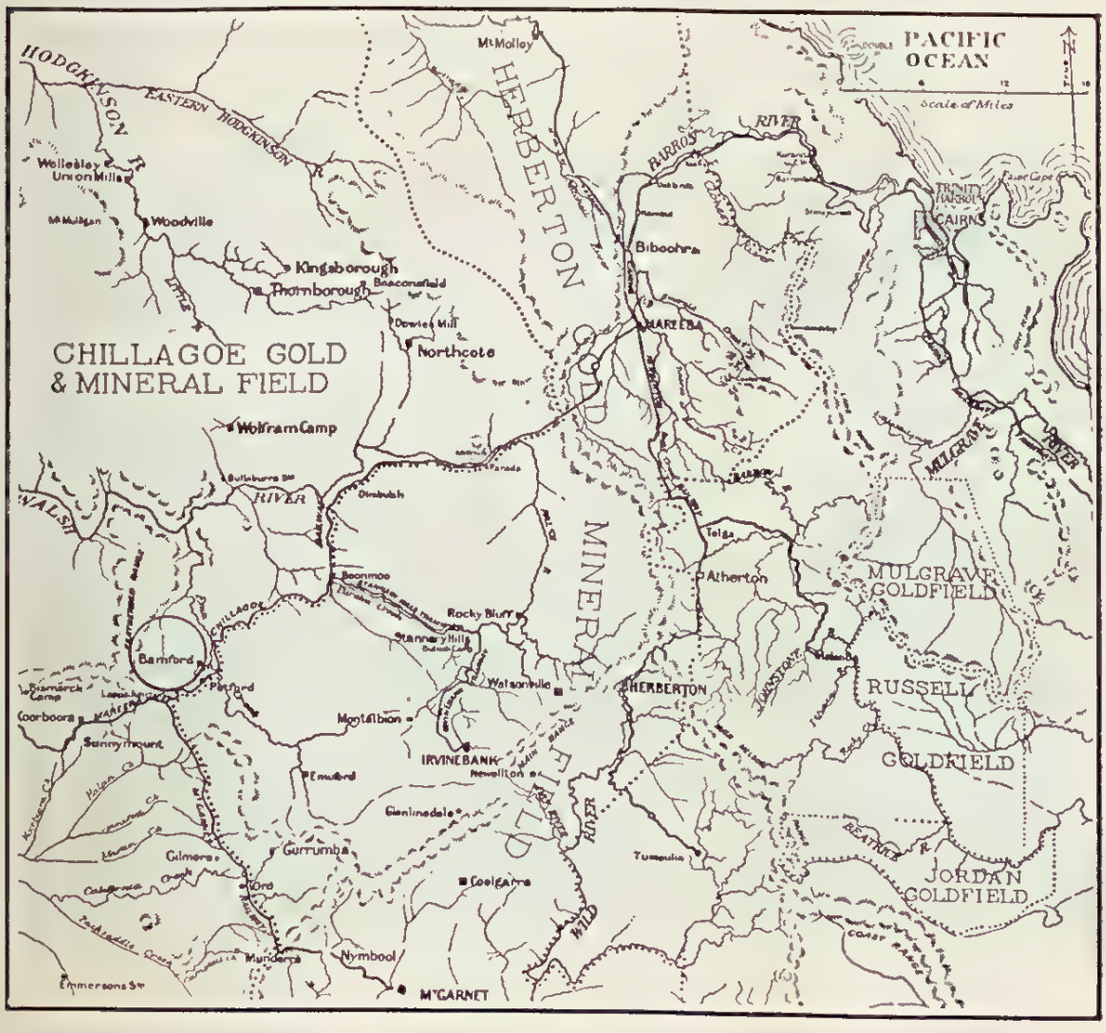
BAMFORD,

NORTH QUEENSLAND.

By L. C. Ball, B. E., Assistant Government Geologist.

INTRODUCTION.

Bamford, the oldest of the rare metal producing centres of Queensland, is situated on a small tributary of Emu Creek, in the valley of the Walsh. It is 1½ miles north-north-west of Petford, a railway station on the Chillagoe railway, 97 miles from the port of Cairns, and 1,577 ft. in elevation above the sea



Locality Map.

(as determined by the Railway engineers). Bamford Hill, on which most of the claims are located, rises to a height of 2,100 ft. (by aneroid) and directly overlooks the township, its summit being but one mile away to the north-north-west.

That wolfram occurred on Bamford Hill was well known to the early tin and lead miners of Lappa Lappa, but we are without reliable information as to when the first shipments were made. Mr. Rollinson informed me that in 1893 or 1894 he sold 28 tons of wolfram at £12 per ton, but Mr. W. Freeman, who shipped 5 tons to Sydney in 1896, is usually credited with being the prospector of the field. Large leases were surveyed in 1898; but a proposal to erect a stamp battery did not eventuate, and the field remained very quiet until 1903, when three hotels and a store sprang up and new miners to the number of over a hundred set to work. During the following year there were between 200 and 300 men in the locality, and the township had a greater population than Wolfram Camp. In 1905, however, with the exhaustion of the rich alluvial, a decline set in, and 1906 saw less than 100 men employed. The gradual falling off continued, and in June 1912 the estimated number of working miners was but 40, the total population of the township being then 167 souls. A few of the miners had homes in the township,

PHOTO. 1.—BAMFORD

VIEWED FROM ACROSS THE CREEK TO THE NORTH-WEST

but some preferred to camp on their claims and save a daily climb thereto. The business places comprised a hotel (the last of the three), a butcher's shop, and a general store.

An exact statement of the total mineral production of Bamford cannot be advanced, for the reason that during the earlier years no returns were made. The best that can be done under the circumstances is to accept the incomplete figures culled from various sources and scattered through the following pages. These, summed, give a minimum total production of 1,581 tons of wolfram, 50½ tons of molybdenite, 15½ tons of bismuth, and 5½ tons of bismuth-wolfram concentrates.

The mining industry of Bamford was at a very low ebb when the place was visited by me in June, 1912. This condition of affairs had been brought about primarily by the exhaustion of the rich surface shoad deposits, commonly misnamed "alluvial"; but contributory causes were the gradual impoverishment of the pipes in the deeper ground and the increasing cost of mining the ore therein. The locking up of the greater part of the wolfram-bearing ground in leases held by a few men is regarded by many as a factor of some weight affecting the present stagnation. It is now plain that to greatly augment the output of concentrates and prolong the life of the field a revolution in the methods of mining and treatment will have to be brought about. Instead of "following the metal" showing in the pipes and more than likely narrowly missing bonanzas, some system of prospecting the whole of the contact formation will have to be thought out, and a scheme to exploit not only the richest pipes but much of the surrounding ore-bearing silicified country now left standing must be devised. Needless to say, steam hauling and pumping plant, replacing the present windlass and whip, will help to allow of lower-grade ore being attacked, and the erection of modern milling machinery on the field would at once convert most of the present mullock tips and many a poor face into payable ore.

I have to express my thanks for the facilities afforded me by the claim holders, lessees, and tributers of Bamford to inspect their workings. Messrs. R. E. Gouge, W. Dangaard, and A. Quill placed me under further obligations by providing me with statements of output of many other holdings than their own, these being of particular value in the absence of official records.

GEOLOGY.

In the light of the advances made since the beginning of this century in our conception of the conditions under which igneous intrusions take place[1] and the results following on these intrusions, including magmatic differentiation, the geology of Bamford can be described in comparatively simple terms.

At some period subsequent to the earliest part of the Permo-Carboniferous epoch, the great series of porphyries that forms the Featherbed Range was intruded by an acid magma, cooling as normal biotite granite; and as inliers of this plutonic rock have been revealed by denudation at many places over a wide area, it is not unlikely that the individual intrusions were in the nature of laccolites—wide spreading mushroom-shaped stocks connected with the interior zone of fusion by relatively small necks. The magma in contact with the porphyry crystallised without appreciable differentiation; but the cooling was rapid and shrinkage sufficed to develop well-marked jointing that later played an important part in the formation of the ore-deposits. The slow crystallisation of the main mass was accompanied by the expulsion of the more mobile constituents, otherwise known as mineralisers,[2] of which, after water, the chief were various fluorides, chlorides, borates, tungstates, &c. These collected under high pressure in the open joints of the overlying contact zone, and thence gradually penetrated the cool granite; being at an elevated temperature and in a state of extreme ionisation, they had a most destructive action on the silicates of the rock, which within the range of their activities was changed to quartz-rock and greisen containing greater or less quantities of bismuth, molybdenite, and wolfram. The chief repositories of these minerals are however the quartz pipes, which are perhaps the most puzzling features of the wolfram fields. I doubt if they can be explained as replacement deposits of any variety, and as

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[1] The subject is fully discussed in the latest text books, among which may be mentioned:—The Natural History of Igneous Rocks, Alfred Harker, 1909; Igneous Rocks, Joseph P. Iddings, 1909; Igneous Rocks and their Origin, R. A. Daly, 1914. Another work, by Mr. E. C. Andrews, of the Geological Survey of New South Wales, on "The Geology of the New England Plateau, with special reference to the granites of Northern New England," should also be cited as of more than local interest.

[2] Harker's "Natural History of Igneous Rocks," pp. 286-7.

an alternative venture to suggest magmatic gas stoping with change from crystalline granite to colloidal silica, subsequently solidifying as crystalline quartz.

Knowing full well the advantages offered by the wolfram deposits of North Queensland as a field of research, I am seized of the shortcomings of the present work as an exposition of the geological facts. Possibly too great an area of country was traversed during the season, that at Bamford being but a small fraction of the whole. Then again, my opportunities to personally examine the occurrence of the metallic minerals were not at Bamford all that could be desired, as it happened that during my visit most of the working faces were "off the metal." Lastly, for various reasons an inordinate length of time has been allowed to lapse between the field work and the writing of the report.

The literature dealing with Bamford is by no means voluminous. We have first of all in the "Queensland Government Mining Journal" the reports of the various gold Wardens and the Inspectors of Mines, in particular Mr. S. H. Horsley; the annual reports of the Department of Mines; a short report by Mr. W. E. Cameron, B.A., Assistant Government Geologist, on "Wolfram and Molybdenite Mining in Queensland" (G.S.Q. Publication No. 188); brief notes by Mr. B. Dunstan, F.G.S., then Acting Government Geologist, on "Wolfram in Queensland" (appearing in the A.R.D. Mines for 1904 and later in the "Q.G.M. Journal" for August, 1905); and lastly the writer's résumé of field studies on "Rare Metal Mining in Queensland" that appeared in the " Q.G.M. Journal " of January, 1913.

Porphyry.

The oldest rocks of the district are the massive porphyry lavas and tuffs that are so widely distributed and bulk so largely in the scenery of the Herberton and Chillagoe mineral fields, occurring in the Silver Valley,[1] near the Dividing Range, stretching out from Mount Mulligan towards O.K., and persisting from Wolfram Camp to Bamford and to Koorboora, so forming the major part of the Featherbed Range. There is every reason to believe them contemporaneous with the massive porphyries of the Newcastle Range on the Etheridge mineral field, and they are considered to be of lower Permo-Carboniferous age, but they may possibly belong to the Carboniferous.

[1] Monograph on the Geology and Mining Features of Silver Valley, Herberton, N.Q., Part I., p. 10. By James Stirling, late Government Geologist of Victoria.

The porphyries are remarkably free from jointing, and to that we must attribute their complete want of ore-bodies at this centre. For the same reason they must have served effectively to dam back the rising metalliferous magmatic solutions over a wide area, the channels of escape being mostly limited to the crest or cupola of the laccolith, now of course denuded; but the patches of pegmatite in the porphyry, several feet out from the contact, on Rocky Creek towards the northern end of the Bamford workings, tells us that the vapours must have searched out some joints lower down the slope.

The stanniferous deposits in the porphyries of Lappa Lappa, some miles to the west of Bamford, may be cited as occupying such vents above a still hidden laccolite.

Typically, the Bamford porphyry has a bluish cryptocrystalline felsitic base with sporadic phenocrysts of quartz (averaging 1/10 in. in diameter) and felspar (averaging 1/5 in. in diameter), both pink orthoclase and creamy plagioclase, the latter with polysynthetic twinning, being present. The rock at the Tank on Emu Creek gorge has the appearance of an indurated tuff, and the aspect of a polished surface of a specimen from near the contact on the Northern United is also distinctly clastic. The porphyry of the hills in the vicinity of the Bamford mines weathers nearly always into small kernels dark in colour and rough from the exposed quartz phenocrysts. The derived soil is mostly reddish and it supports a characteristic ironbark forest vegetation.

The porphyry of the Dover Castle differs slightly in its finer grain and in having its phenocrysts corroded. Again that on Lappa Hill to the north of Lappa Junction is a fine-grained greenish quartz-felspar porphyry with well-marked fluxion structure.

Granite.

The Bamford granite massif has an extreme length from north to south of nine miles and a maximum width of five miles. In two places it contracts to less than a mile. It is thus three lobed, but is otherwise most unsymmetrical in plan.

At the nodes we are quite close to the original upper surface of the massif as illustrated in the sections taken from the map and the attached diagram.

Though the crop of the contact between the granite and the overlying porphyry can usually be defined without much trouble it is nowhere very well exposed; and even in Rocky Creek at

Fig. 1.—The Granite Area of Bamford. (Shaded.)

the northern end of the field where the workings come down on to and cross the contact exact observations are not possible because of the decomposition of the country on either side. Further, a satisfactory delimitation of the crystalline granular rocks below Lappa Junction Railway Station was not found feasible in the available time. In the valley at Petford we have intrusive biotite granite and on the Feather-bed Plateau to the west of Lappa Junction we have the volcanic porphyries, but

on the flanks of the range between the two there is developed a most complex set of rocks, remaining to be investigated.

Neglecting all islands or outliers of porphyry the main contact line has a length of 35 miles. The lowest exposed points of the contact are on Emu Creek and its tributary Rocky Creek, the highest being on the Razor Edge, a spur of the Featherbed Range. In the productive part of the field the contact plane commonly dips at an angle of about 45° away from the granite area, but in one case it has been found to turn over in depth, and we may have in this an indication of the laccolitic form.

As a rule, the granite appears to have had no action on the overlying porphyry.

The unaltered more plutonic granite exhibits exfoliation on a huge scale, whole hillsides being formed of domed monolithic masses of the rock. Small kernels, on the other hand, are seldom seen. On account of its granular texture the rock submits readily to decomposition to a white sandy soil, and subsequent denudation is rapid. Hence the granite area is one of low elevation in contradistinction to the older fine-grained porphyries, which are simply gapped or gorged by stream action where the

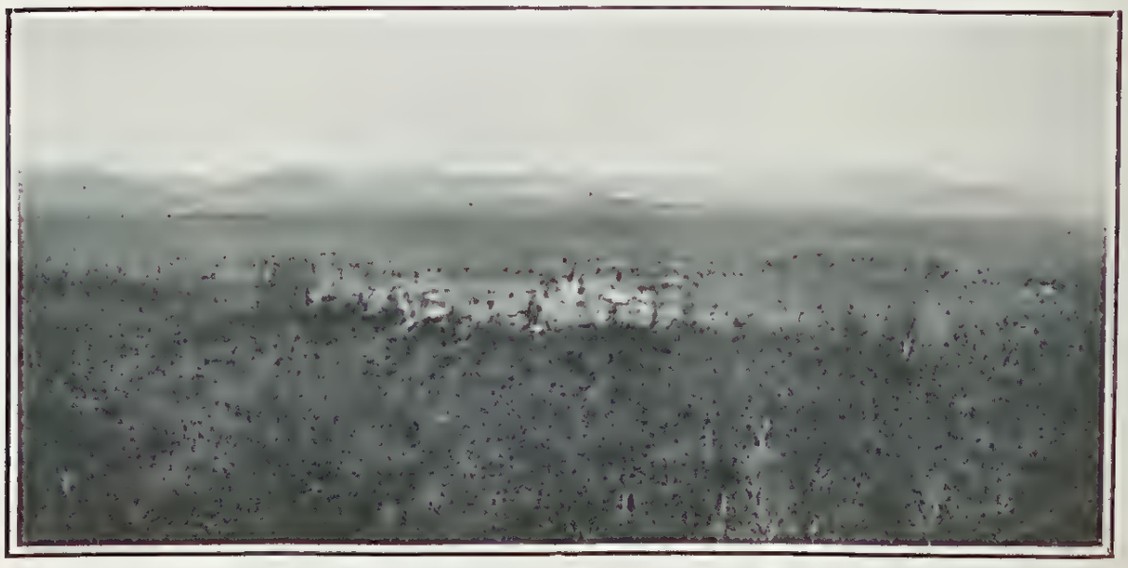

PHOTO. 2.—BAMFORD AND THE VALLEY OF EMU CREEK FROM THE ADAVAL.

granites open out into wide-spreading valleys. As an instance, compare the Emu Creek Gorge and the valley above. Wherever the granite forms rising ground we may safely assume that the protective capping of porphyry has been but lately removed.

Such is the case on Bamford Hill, which quite recently, geologically speaking, must have been covered by an arch of porphyry springing from the Razor Edge on one side and from the Gorge Hills on the other. Remnants of this arch are to be seen on Bamford Hill itself, on Sunny Corner Hill, and on several hills between the Razor Edge and Bamford township.

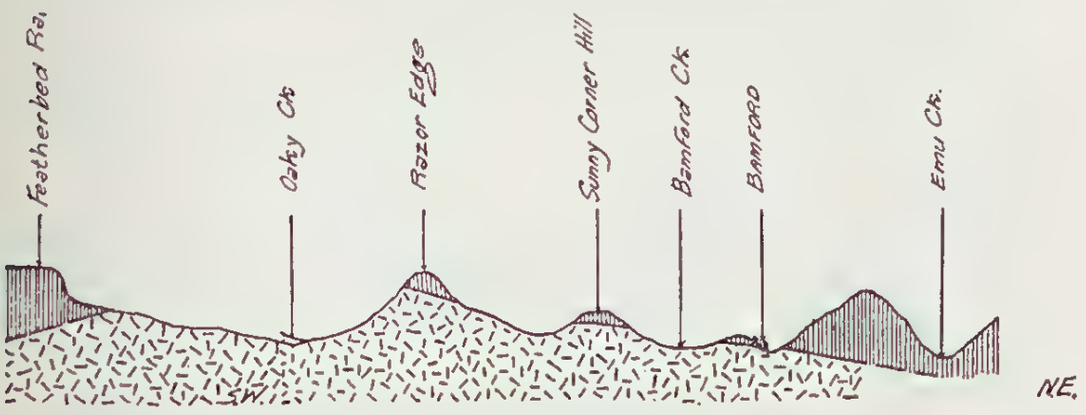

FIG. 2.—SKETCH SECTION THROUGH BAMFORD.

Porphyry and altered sedimentaries—Lined. Granite—Hatched.

At a distance from the porphyry the granite has a granular fabric, but, along Oaky and Rocky Creeks on the eastern side of the massif, it exhibits a porphyritic habit, and in the contact zone graphic and pegmatitic structures may be observed.

As to the component minerals, quartz is of course predominant, usually in the granular state without any tendency to idiomorphism. Orthoclase is always abundant and the multiple twinning of plagioclase may usually be recognised by means of a pocket lens, the presence of soda-lime felspar being also indicated by the strings of calcite in the decomposed rocks and by the scheelite in the oxidised parts of the ore-bodies. Biotite is sometimes scarce but never absent, though some of it may have been altered to a chloritic material. In three cases also wolfram was recognised as apparently a primary constituent of the granite, but all these, be it noted, were within the contact zone. It was first found distributed along defined lines crossing rather than following the jointing of the porphyritic granite of the Two Jacks, and that without any apparent textural variation in the rock itself. Next it was found in unaltered biotite granite on the Ballarat. This case seems worthy of further description and is illustrated herewith. The quartz felspar and mica are quite unaltered and it will be observed that the rock has a granular structure, the wolfram occurring in actual contact with and

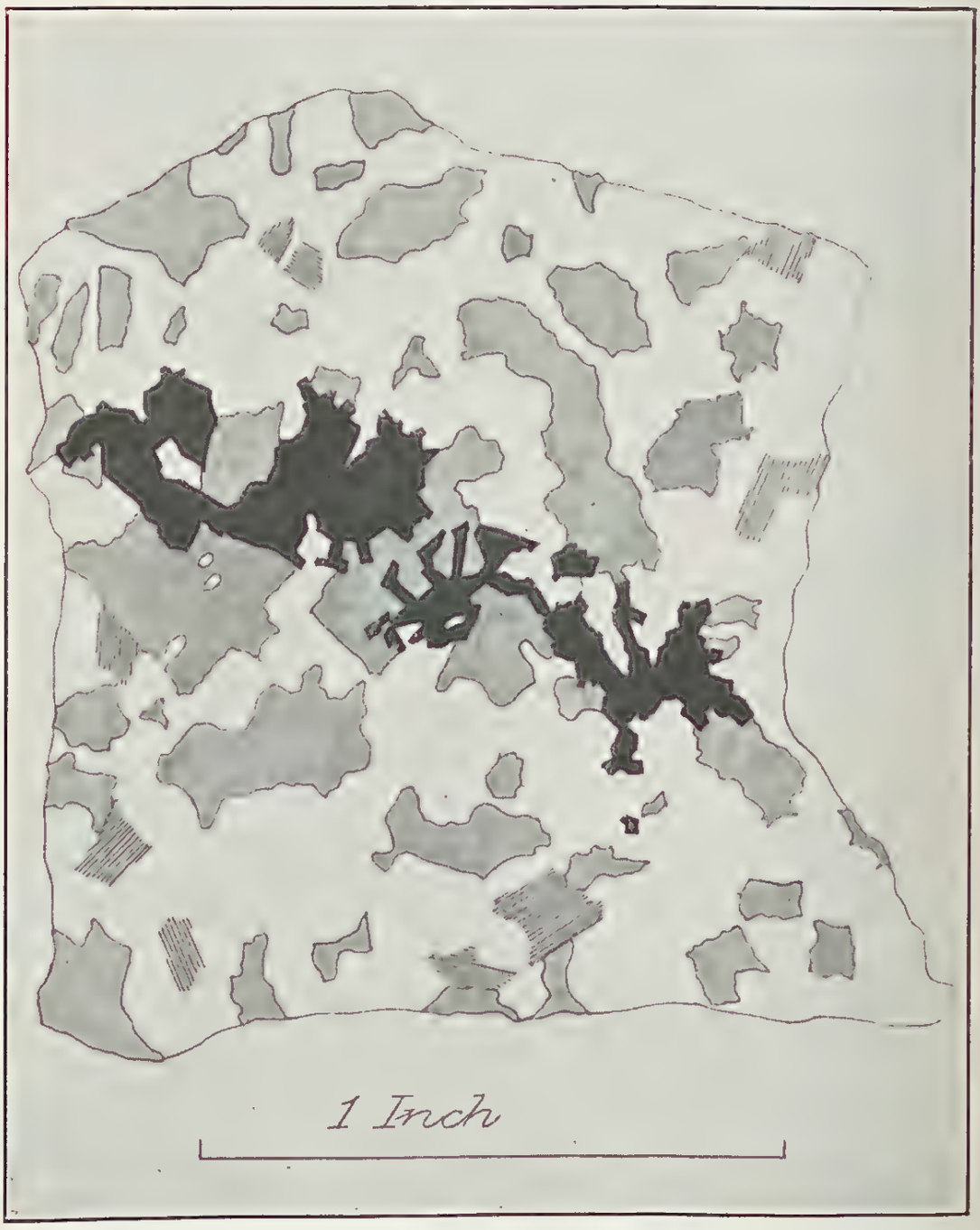

FIG. 3.—WOLFRAM IN GRANITE, X4, BALLARAT.

Black—Wolfram. Lined—Biotite. Grey—Orthoclase. White—Quartz.

penetrating both quartz and felspar. Lastly, wolfram was found near the Dane's shaft on the Northern United, where, however, the granite has a proneness to assume the graphic structure.

Greisen.

Greisen results from the action of various mineralisers upon granite. At Bamford, we have all stages between slightly greisenised granite (wherein the felspar is slightly kaolinised, the biotite chloritised or changed to muscovite, and the quartz much

in excess) and quartz-rock with little more than traces of silicates. The term greisen is employed in the following pages to denote a granular admixture of quartz and muscovite, with one or other mineral, but usually the quartz, greatly in excess. Massive pyrite is an accessory constituent, being crystallised in vugs, and both molybdenite and wolfram occur in the rock. Orthoclase was noticed at the Gray and biotite was seen at the Rollinson, both being out of the usual. Topaz has not been detected in the greisen of Bamford, though plentiful on certain other wolfram fields in North Queensland.

The slightly greisenised granite of the Trafalgar has an abnormal quantity of quartz. Some of the felspar is still fresh, and exhibits polysynthetic twinning, but some has been removed in part and probably some has been completely replaced. The biotite has been changed to chlorite and a few flakes of bright silvery muscovite have appeared, while there are also bunches of molybdenite in ¼-in. crystal flakes. Where pneumatolysis has been more intense the rock is made up chiefly of pale blue to granular quartz with distributed specks of chlorite, a few bright spangles of mica, and scattered crystal flakes of molybdenite. The minute brown acicular crystals often arranged in plumose rosettes in the altered granite of the Two Jacks have been tentatively diagnosed as tourmaline, a mineral not recognised elsewhere on the field.

Quartz-rock.

The quartz-rock enclosing the "spar" pipes is commonly known by the miners of North Queensland as "bastard spar." It consists almost entirely of a bluish crystalline-granular quartz, often much cracked and with miarolitic interspaces (that is, spaces bounded by crystal faces), some of which contain flakes of muscovite or a chlorite mineral (altered biotite?). Exceptionally a little white kaolin, derived from felspar is seen in the cavities, and in one case granular magnetite was observed (*see* Cornishman). Both wolfram and molybdenite may occur in this rock, the former mostly in small laths, the latter as crystal books; and bismuth has also been noticed in the interspaces. Pyrite is a comparatively rare accessory and actinotite was found in the rock at one point only.

It is plainly evident in the field that "bastard spar" is simply silicified country, one stage beyond greisen, through which all the gradations may be observed back to fresh unaltered granite.

Graphic Granite.

Graphic granite, a variety of aplite with characteristic arrangement of included quartz, may be regarded as a solidified residual entectic mixture derived from the differentiation of a granitic magma; and it might naturally have been expected in such a contact zone as this; but its development was noticed at only a few spots.

At the northern end of the field on the Two Jacks it occurs as bands 7 or 8 in. wide on either side of a flat dipping joint in the granite a few feet below the porphyry cap. The granite of the Ballarat encloses small nests of molybdenite-bearing quartz, and within a few inches of these nests its fabric changes from granular to micrographic. In the same quarter, at the Dane's shaft on the Northern United, the quartz and felspar of the granite have intercrystallised and a graphic structure is distinguishable in places. The only other discovery of graphic granite was made towards the southern part of the worked area, where a small vein of the rock is exposed in Peters' claim in Bismuth Gully. This consists of intercrystallised quartz and plagioclase (probably albite), the latter in great excess, with a few adventitious spangles of altered biotite.

Pegmatite.

Pegmatite consists essentially of very coarsely developed but not necessarily definitely oriented quartz and felspar, derived from the residual mother liquors of the solidified granitic magma. It is seen in quantity only at the northern and southern ends of the line of workings and beyond the richer ground—*i.e.*, to the south of the Sunny Corner and to the north of the Ballarat; but the granite on the southern slopes of Bamford Hill is extremely variable in composition and in places is almost coarse enough to be called pegmatite.

At opposite ends of the field on the Enright and Thompson and on the Two Jacks the orthoclase occurs as scattered phenocrysts ¼ to ¾ in. in length in a milky white crystalline vitreous quartz; and from the latter place comes also coarsely pegmatitic quartz-orthoclase rock with occasional large crystalline masses of felspar, having attached laths of wolfram.

The former presence of pegmatite in the ore-bearing pipes is denoted by the wolfram-bearing kaolin and crystallised quartz-filled vugs of many of the mines, including the Northern United,

Haymaker, and Dog. The occurrence of such surrounded by considerable thicknesses of quartz-rock, a granite from which nearly all trace of alumina has been removed, points strongly to the pegmatite having crystallised from magmatic liquors subsequently to the main emanation of mineralisers.

Felsite.

Dykes of felsite have been found traversing the contact zone in the northern, central, and southern sections of the field, respectively on the Northern United and Ferguson United, on the Morning Star Extended, and on the Sunny Corner.

These, in that they intersect the quartz-porphyry, the granite, and the contact deposits, are manifestly the youngest of the igneous rocks. The dykes are most variable in size, that in the quartz-porphyry on the Northern United being only 6 in. thick, while that in the quartz rock of the Morning Star Extended swells out to 30 ft. width in places. The constitution is the same in each case: a very fine-grained greenish or purplish felspathic base with sporadic zoned or skeletal crystals of felspar and very minute specks of quartz.

These dykes have exerted no influence on the deposition of the ore, nor do they seem to have in any case caused or followed faulting of the ore-bodies. Their effect in mining is then simply the interposition of a greater or less thickness of barren ground to be driven or sunk through.

ORE DEPOSITS.

The popular belief that wolfram-bearing pipes are the most erratic of all ore deposits, and that wolfram and molybdenite are among the most difficult of minerals to follow underground, has in reality a strong basis of truth. However, many of the miner's troubles would be lightened if he had some conception of the manner of formation of the ore-bodies; and the conditions at Bamford will therefore be briefly discussed in the following pages, with particular reference to the question of genesis. A magmatic origin has already been postulated, and it will first be desirable to point out the governing influence of the jointing of the enclosing country-rock.

Joints.—Whatever be the external structure of the batholyth, we know that, under the stresses superinduced during the solidification of the magma and its contingent shrinkage, relief will have been derived by fracturing, which is most commonly expressed in granitic rocks by the sets of sub-parallel joints; and at Bamford as a matter of fact the joints in the contact zone are very pronounced. The master-joints, but slightly less inclined than the porphyry contact surface, have had the most potent influence in directing the final trend of ore deposition, for it has been found that most of the pipes pitch along them. The steeply inclined subsidiary joints on the other hand have been of no less moment in that they provide conduits for the mineralisers and ore-bringers, and under favourable circumstances some actually became the loci of ore deposits.

Form.—Shapeless masses of entrapped white quartz are not uncommon in the blue quartz-rock of the productive ground; and such enclosures have also been noticed in the unaltered granite on the Ballarat, where each is surrounded by a graphophyric aureole; but the ore-bodies proper fill irregular and deformed pipes, which frequently branch and repeatedly give off short spurs. They are subject to tapering, either gradual or acute, and they are specially liable to abrupt truncation on any of the numerous cross joints of the enclosing quartz-rock. Empty pipes are extremely rare, but a drive following a small horizontal ore-body in the granular quartz-rock of the Northern United, between the Tunnel winze and the Main shaft, exposes two tubular caverns overhead. These are 9 to 18 in. in diameter, and some-

times much flattened. Their course is most erratic, and their length could therefore not be ascertained. The surface of the pipes is somewhat rounded in parts and slightly flaky, but again in others it is jagged and encrusted with a few minute drusy crystals of quartz. A little comminuted quartz and mica, produced during the weathering of the wall-rock, was the only other material in the pipes.

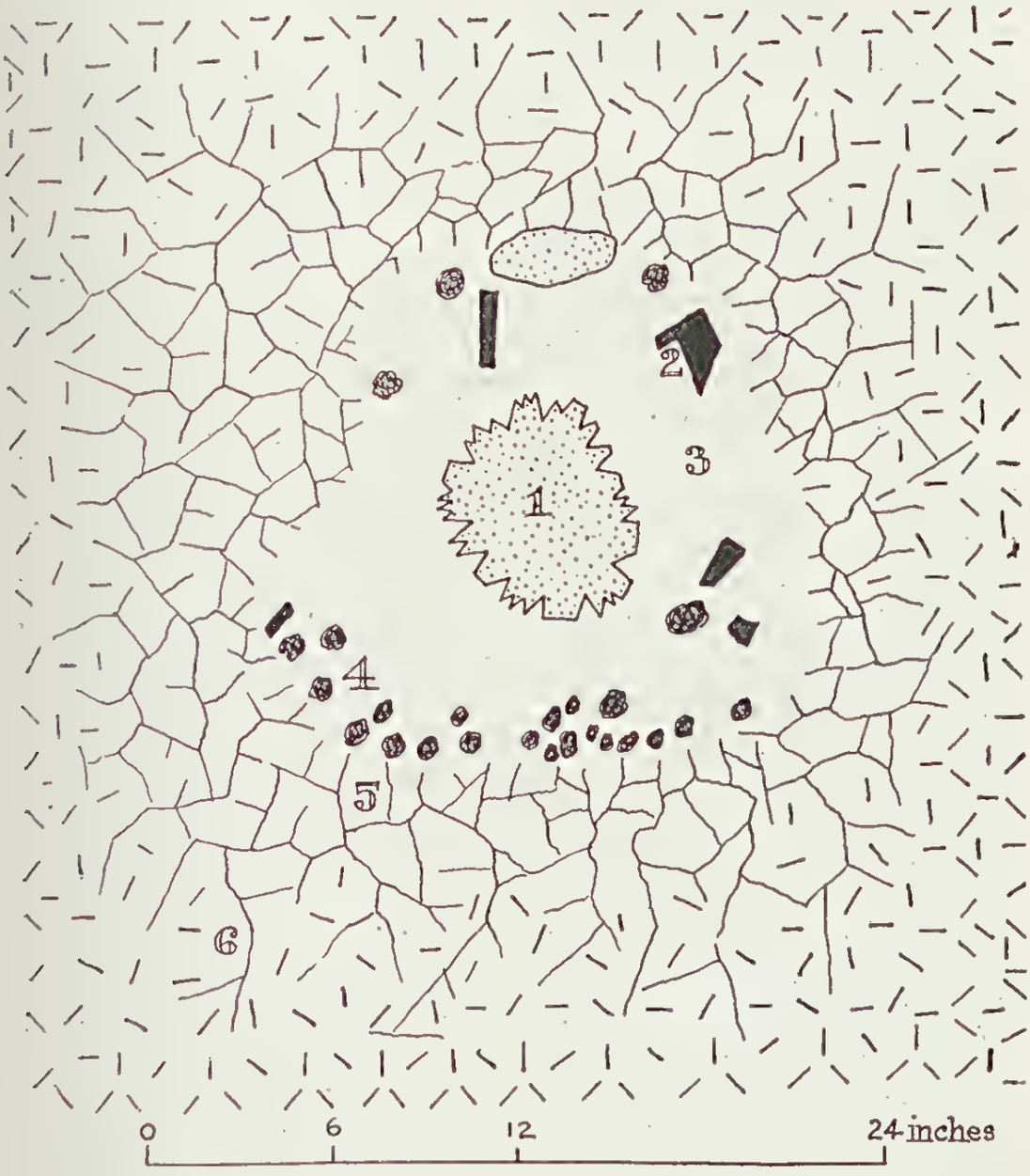

FIG. 4—PIPE AT 100-FT. LEVEL, PETER'S WINZE, MAIN WORKINGS, NORTHERN UNITED.

1. *Vug filled with clay, quartz crystals, etc.*
2. *Wolfram.*
3. *Crystalline white quartz.*
4. *Molybdenite.*
5. *Cracked bluish quartz-rock (replaced country).*
6. *Silicified granite.*

Filling.—The great bulk of the pipe filling is a white crystalline quartz, which contains wolfram and molybdenite in variable proportions. These minerals may within limited spaces form the major part of the ore-body; but in the run-of-mine ore they seldom exceed 1 per cent.; and the average tenor of the pipes worked is thought to have been but a small fraction of that amount. The evidence is plain that the quartz, wolfram, and some of the molybdenite crystallised almost simultaneously; but the introduction of the metalliferous minerals is thought to have been later than the first emanation of mineralisers. Much of the molybdenite occurs in miarolitic cavities and seems to have come in or to have remained mobile till towards the completion of solidification. The bismuth, confined as it is to the vugs and cavities, was still later precipitated.

Vugs.—The vugs or caverns are among the most interesting features of the pipes. They vary from a few inches to a few feet in diameter, and some of the larger ones are 20 ft. or more in length. As a rule when first opened they contain detrital matter, including quartz-rock, greisen, crystalline, and crystallised quartz, and much kaolin. Molybdenite and wolfram occur as constituents of the quartz-rock and "spar," and the kaolin is often stained by the ochres of tungsten, molybdenum, and bismuth, often in quantities that should render them marketable. Scheelite is not by any means rare; and various other molybdates have been detected in certain of the vugs—*e.g.*, those of the Northern United. In some of the deeper vugs various sulphides have made their appearance, and among them are those of iron, copper, zinc, and lead. One other mineral worthy of special mention is fluorite, which sometimes acts as a cement. The smaller vugs of some of the pipes were observed to contain quartz crystals, large flakes of molybdenite and some kaolin, as well as peacock wolfram. The vugs in these cases may be taken to mark the sites of former segregations of pegmatite. The lesser vugs, particularly those near the footwall, seem to be desirable features in that about them increased quantities of wolfram are found. The larger vugs on the contrary are regarded unfavourably by the miners, and the suspicion, rife among those of Wolfram Camp, that if a large vug be met in any particular pipe the lower limit of payable ore is at hand, received some support from at least two cases on the Northern United at Bamford.

The first of these was Truss and Devery's, in which a vug 20 ft. in length was entered just above the main adit, below which

but little ore has been won from that particular pipe. In the other case, that of the tunnel winze, a large vug came in 85 ft. below the adit and the sink is now in poor ore. It is anticipated that the great vug in the sink of the main shaft, 215 ft. from the surface, marks the downward limit of pay ore in its pipe. In the Rollinson United the main shaft passed through a big vug from the 75-ft. to the 85-ft. level, and, though there was very rich wolfram immediately above it, the quartz below is almost barren. In this instance, however, another shoot of wolfram has been found, some feet aside, on the 90-ft. level.

Genesis.—The origin of these pipes has long been a mystery to workers on the wolfram deposits, the theory of metasomatic replacement being wholly insufficient to explain many of their features; and, as we cannot undertake satisfactorily their exploitation while having no idea as to their genesis, I venture to propound an hypothesis to the effect that the residual gaseous emanations of the deeper-seated crystallising granitic magma, on their expulsion from the still highly heated interior, stoped their way into the cooler contact granite, following preferably but not exclusively joint intersections; and that the contorted tubular channels or pipes so formed were simultaneously filled with colloidal siliceous solution derived from the minerals of the rock destroyed.[1]

This is in great part applying the eclectic theory of Daly, who in discussing magmatic stoping says[2]:—

"It is well established that some gases under pressure will form fluid solutions with rock matter at temperatures far below the fusion point of ordinary minerals and rocks. The well-known experiment of Barus represents an extreme case. He found that water and silica in a sealed tube form a liquid at 210° C.[3] Fouqué and Michael Lévy proved that the materials of a very acid granite (79 per cent. of silica) mixed with water in a sealed tube became at least partly fluid at 1,000° C.; though the dry materials did not become 'even viscous' at 1,300° C.[4]"

I venture now to suggest the essential production of colloidal silica from the granite stoped; and in this can claim

[1] We may assume that the gelatinous filling of the empty pipes on the Northern United was drained out into the horizontal pipe of the drive below.

[2] Igneous Rocks and their Origin. By R. A. Daly, 1914, p. 213.

[3] C. Barus, Amer. Jour. of Science, vol. 9, 1900, p. 161.

[4] F. Fouqué and A. Michel Lévy, Comptes Rendus, vol. 113, 1891, p. 283.

collateral support from so eminent an authority as Van Hise,[1] who, however, would derive a "gelatinous magma rich in silica" from the crystallisation of the parent mass.

The numerous vugs strung along the pipes appeal strongly to me as indicative of the original colloidal condition of the silica; for it is to be presumed that, while the silica remained in a gelatinous state and at a high temperature, it offered little resistance to the passage of fresh supplies of magmatic gas, but that as the jelly became viscous the gas was trapped, so forming vugs. In some of the vugs there is evidence of pegmatitic filling, due to the enclosure of an attenuated silicate magma, such as that described by Van Hise.[2] What caused the change from colloidal silica to crystalline quartz has not been ascertained; but in addition to the inevitable fall in temperature the influence of tungstic acid is suspected, it being known to take part in the liberation of quartz from artificially molten magmas.[3] Thorpe in furnishing an example of the mutual coagulation of two colloids mentions the precipitation of egg albumin by solutions of molybdic and tungstic acids,[4] the latter having been artificially obtained as a white gelatinous precipitate, unaffected by rise in temperature to 200° C.[5]

Allowing that gelatinous silica was one product of the action of the magmatic gases on the stoped granite, the absence or extreme rarity of secondary silicates in the pipes requires to be accounted for; and the most feasible explanation occurring to me is that the bases were carried into the adjacent altered rock.

Turning now to the wall rocks, we must here also call in the aid of the pneumatolytic emanations for a satisfactory explanation of the changes wrought. The gases, confined by the almost impervious mantle of porphyry, must have been under immense pressure during the progress of magmatic stoping; so that lateral diffusion into the comparatively cool surrounding granite might have been expected, and has I think generally been assumed. Though necessarily less active than the gases in the pipe, they continued for a time to attack the silicates with dissolution of alumina, iron, magnesia, lime, soda, and potash, perhaps with coincident precipitation of silica, wolfram and molybdenite,

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[1] A Treatise on Metamorphism. By C. R. Van Hise, 1904, p. 722.

[2] Idem, p. 722.

[3] See "The Data of Geochemistry," by F. W. Clarke. 2nd Edition, p. 343.

[4] Dictionary of Applied Chemistry, vol. II., p. 115.

[5] Idem, pp. 567–8.

though these last may have been introduced later. Thus was formed the quartz-rock or "bastard spar." Further afield the now chemically enfeebled solutions were able to dissolve only the felspars or to alter them to quartz and muscovite or to change the biotite to muscovite, chlorite, quartz and magnetite, so manufacturing greisen. In this part also some of the earlier dissolved bases were thrown down as muscovite, and there we get mica-rock, often containing molybdenite, wolfram, and bismuth.

Productive Zone.—We might reasonably have expected the whole periphery of the intrusive dome to be a favourable locus for mineralisation and ore deposition. Such, however, is not by any means the case, as a glance at the mapped contact will make clear. It is more than probable that the summit of the massif, in that it cooled first and most rapidly and probably suffered most from the effects of contraction, was the goal of the rising emanations; yet in following any line of contact this assumption time after time fails to completely explain the vagaries of the ore occurrence. An interesting stage in the cycle of denudation has been reached at Bamford, where long stretches of both high and low parts of the contact surface are exposed. The accompanying map shows that metallisation has been restricted not only to the vicinity of the contact but further to a narrow zone extending from south-west to north-east, passing from view under thick masses of porphyry at either end of the productive area. Looking a little more closely we notice that greisenisation too is confined to the actual contact only in the northern and southern parts of the field, the greisen in the central part being separated from the porphyry by a considerable thickness of unaltered granite, much less jointed than usual. It is estimated that the greisenised zone has a width of between 50 and 100 ft. on the Rose of Denmark and the Rose of Queensland, but immediately to the north it tapers away to nothing, and southwards its thickness is variable.

MINERALOGY.

It has already been shown that at Bamford the metallic ores are confined to the contact greisen, and the subjacent granite, owing to there having been scarcely any escape of the ore-bringers into the overlying porphyry. The field investigations indicate that the tungsten was probably not a constituent of the earliest pneumatolytic emanations, though wolfram was thrown down during the crystallisation of the pipe-quartz. We might have assumed the tungsten to have volatilised as the hexafluoride were it not that the salt is converted into tungstic oxide and hydrofluoric acid by contact with water. Granite contains iron and manganese oxides in the proportion of about 1 per cent. and 0·1 per cent. respectively. The quantity set free during the decomposition of the silicates of the now silicified and greisenised granite will thus have been ample for the neutralisation of any introduced tungstic acid. In some cases the excess of iron has separated as magnetite. Molybdenum, bismuth, copper, zinc, lead, and iron all occur as sulphides, but they are not all of one age. Thus most of the molybdenite was precipitated contemporaneously with the quartz and wolfram, though some of it remained to be crystallised in vugs. A very little of the bismuth came down with the wolfram and molybdenite, most of it being distinctly younger than the crystalline quartz and quartz-rock, the miarolitic cavities of which are its home. The proper habitat of the copper and iron sulphides is the vugs, but they are found too with molybdenite in the neighbouring greisen, as also, less frequently, is the sulphide of zinc. Lead sulphide on the other hand has been noticed nowhere except in vugs. Various secondary oxidation products including tungstates, molybdates, and the ochres are characteristic of the vugs. Besides quartz and the secondary silicates of the quartz-rock and greisen, among which muscovite, kaolin, and chlorite may be mentioned, only one important gangue mineral, viz., fluorite, was observed in a few of the vugs; but the occurrence of some calcite is recorded below.

In the foregoing it has been assumed that the metals were all present at the same time in emanations, and that their order of deposition depended on their relative volatility and solubility. Field associations suggest, however, that this may have been

only partly true, and that the earlier gaseous emanations were richest in tungsten and molybdenum, the last of the mother liquor containing the commoner metals, which may have been deposited at a higher or lower horizon depending on the then temperature of the rock entered and the presence or absence of a precipitant.

The first critical official examination of the ores of Bamford was made in 1904 by Mr. Dunstan, now Government Geologist, whose published contributions to the elucidation of the occurrence of wolfram, molybdenite, and bismuth will be found in the Annual Report of the Department of Mines for 1904, p. 150. In addition, Mr. Dunstan recorded in the Survey files the following associations:—wolfram, molybdenite, bismuth, bismutite, scheelite, molybdite, mispickel, and scorodite with traces of chalcopyrite, tenorite, chrysocolla, pyrite, &c.

During the present year there has appeared in print the "Queensland Mineral Index," wherein bismuthinite, galena, and blende are added to the record. The list has now to be swelled to include four other mineral species—viz., fluor, ilsemannite, powellite, and monazite. The complete absence of tinstone from the central productive area is noteworthy.

My own notes on the minerals of Bamford are appended in alphabetical order:—

Actinolite (silicate of lime, magnesia, and iron) is met in crystalline granular quartz at the Adaval and Creighton. The needles, which are rhombic in cross section and are deeply striated longitudinally, are 1/100 to 1/20 in. in diameter and up to ½in. in length. In certain parts the minerals have suffered change to a cream-coloured fibrous substance. The same deeply striated brownish rhombic prisms occur in a chloritic quartzose rock at the White Elephant.

Azurite (the blue basic carbonate of copper) was observed as a staining in sericitised mica rock at the Ballarat.

Bismuth occurs at Bamford in several different combinations, but almost always anhedrally; in the native or metallic condition as silver-white sub-micaceous masses subject to rapid tarnish to a golden bronze; as the dull lead-coloured well-cleaved and frequently acicular sulphide; as amorphous carbonate, mostly mouse-coloured, sometimes dark yellow (when it probably contains tungstic acid), and often streaked or tesselated with dark grey; and, lastly, as yellow ochre sometimes containing

important amounts of tungstic and molybdic oxides. The bismuth minerals are found most plentifully in the cellular quartz-rock surrounding the pipes, but they appear in quantity also among the vug fillings. Only very rarely do they penetrate the accompanying minerals, and it is presumed therefore that bismuth was the last metal thrown down. Bismuthinite is a common associate of molybdenite, with which it may be interlaminated, thereby depreciating its value. The wolfram concentrate from one of the greisen shafts on the Trafalgar contains 15 per cent. bismuth, an altogether out of the common amount. Among the sulphides, galena from one of the Rose of Queensland vugs has been shown by assay to contain 2·8 per cent. bismuth; and the hand-picked copper ore of the Gillian and Bridge, assaying 16 per cent. copper, carried enough bismuth to render it unmarketable.

Native Bismuth is the most common near the surface, and it occurs practically always interstitially in the crystalline or granular quartz rock, mostly in sharp-edged nuggety forms, but it has also been observed in thin sheets in the quartz, and at the Morning Star Extended it has been found as small tapering rods penetrating crystallised wolfram. There rods are 1/50 to 1/10 in. in diameter, but are seldom more than ½ in. in length. In section they appear to be oval. Their orientation bears a constant relationship to the crystallographic axes of the host.

Bismuthinite (the sulphide) is, like native bismuth, mostly interstitial in the quartz, but it has been observed as needles in the massive chalcopyrite of the Gillian and Bridge, as ½-in. rods among the sulphides of the Northern United, and again in fine needles penetrating fluorite on the Rose of Denmark. Bismuth, to the extent of nearly 3 per cent. and probably present as the sulphide, has been detected by the Government Analyst in galena from a vug on the Rose of Queensland.

Bismutite (the carbonate) is frequently observed as an oxidation product of the sulphide and the native metal, kernels of which are quite usual. Much of the bismuth of the vug fillings is probably in the state of carbonate.

Bismite (the oxide) stains are observed in the oxidised zone wherever the above minerals are found, and it sometimes completely replaces them, as in the case of a small rod piercing wolfram on the Haymaker, and others in peacock wolfram at the Northern United. In places, as at the Trafalgar, it pays to crush the rock for the recovery of the ochre.

Blende (sulphide of zinc) is restricted in its occurrence to the vug fillings and to the adjacent greisen (at the Gillian and Bridge). It is common in crystalline masses, some of it light yellow in colour, but much of it jet black. The dark brown translucent mineral obtained in the Rose of Denmark reacts for cadmium. In the vugs the blende is associated with pyrite, chalcopyrite, and galena, probably simultaneously deposited. It is sometimes enclosed in a clayey matrix, or otherwise in a siliceous cement and rarely, as at the Rose of Queensland, in fluorite.

Cassiterite or tinstone (the oxide of tin) has not been discovered actually at Bamford, but the mineral occurs as minute jet-black lustrous subconchoidal grains in a saccharoidal vitreous quartz rock at Gabriel's claim between Bamford and Lappa Junction.

Cerussite (carbonate of lead) is believed to occur in the earthy filling of the large vug in the main shaft of the Northern United, but its separation from the associated tungsten minerals has not definitely been effected.

Chalcopyrite (the yellow copper-iron sulphide) has been detected with pyrite in the greisen near certain of the pipes, but its proper locus is in the vugs of the quartz, where it is associated with pyrite, blende, galena, and bismuthinite. Some of the Gillian and Bridge ore when hand-picked carried 16 per cent. copper, while the sulphides from the Marseillaise ran 9·8 per cent. copper.

Chillagite (the tungsto-molybdate of lead) may be a constituent of the yellowish crystalline vug filling at the 200-ft. level of the Northern United.

Fluorite (fluoride of lime) is a comparative rarity at Bamford, but at the Northern United it is found in all the vugs and was noticed at a few other mines. It would seem to occur only as a vug mineral cementing quartz and the various sulphides, and from this we may infer that it is one of the latest deposited. The fluorite is white, purple tinted, light emerald green, amethystine, and light blue. Fine crystals 2 to 3 in. square have been found deposited on quartz crystals at the Rose of Denmark and the Rollinson, and these have pronounced octahedral cleavage. Fluorite also occurs veining the granite at the Petford Spring, 4 miles south-south-east of Bamford Hill. It is there mostly crystalline granular translucent light green and white, but it occurs also crystallised in cavities. The spring now deposits opaque thinly laminated white to creamy calcacous sinter.

Galena (sulphide of lead) has been noticed in the vug fillings in three mines and in the greisen of one. That from the vugs in the main shaft of the Morning Star Extended includes part of a crystal showing combined cube and octahedron; but one quartz crystal-lined cavity was filled with crystalline galena and blende. It occurs with blende and chalcopyrite in the siliceous cement of the vug at the 80-ft. level, Northern United; and it occurs with crystallised pyrite in another vug. Granular galena was got in some quantity in the Rose of Denmark vugs, and in one case it included brown blende and was set with masses of that mineral and fragments of zoned quartz, in puce-coloured fluorite. The bismuth-bearing galena from the adjoining Rose of Queensland has on assay yielded 74·2 per cent. lead, whereas the Marseillaise sulphides assayed but 4·6 per cent. The single case noticed of greisen enclosing nests of galena was at the Frenchman's shaft on the Trafalgar.

Hæmatite (sesquioxide of iron) is not common in these mines. The blue-black crystalline granular slightly magnetic form of the Adaval, Cornishman, and Dog are probably oxidised magnetite. The more strongly magnetic mineral also occurs with concentrically marked indistinctly radiated structure and splendant bands at the Dog, the Gray, and the Morning Star Extended, and there also is secondary.

Hyalite (hydrous silica) was observed as a coating on jasperoid occurring at the Sunny Corner.

Ilsemannite (the blue molybdate of molybdenum) was observed at the Dog, Enright and Thompson's, and Northern United as slight stains in the vug kaolin and in the crystalline molybdenite-bearing quartz on the dumps. It was, however, noticed in quantity only at the Gillian and Bridge, where it occurs in vugs among interpenetrating crystals of quartz. It is an earthy substance, shading off from light turquoise blue into blue-black, and is soluble in cold water, the solution readily reacting for molybdenum. This mineral has not previously been recorded from Queensland, and is indeed one of the rarest species known.

Kaolin (hydrous silicate of alumina) is found with quartz crystals in the large vugs and as a selvage on joint planes, but it mostly occurs interstitially in crystalline and crystallised quartz, where it sometimes contains wolfram. It is a residual product of the decomposition of felspar, which, with the included quartz, often in much distorted crystals, made up the rock pegmatite. From the fact that most of the felspar of the rock

surrounding the pipes has been wholly removed we may be reasonably sure that the pegmatite is of later date than the greisenisation.

Limonite (the brown hydrate of iron) in the form of gossan is met with in plenty in the vugs, where sometimes the porcellanous variety is also met.

Magnetite (ferrate of iron) is found in crystalline granular state in quartz, as octahedral crystals (with strongly marked octahedral cleavage) in mica rock, and in dense crypto-crystalline form in chloritic matrix. Some of that in the quartz of the divide ½ mile north-west of the Sunny Corner is in process of alteration to hæmatite. The most interesting occurrence, however, is that at the Dog, this exhibiting pronounced polar magnetism. It is crystalline granular and is contained interstitially in crystalline quartz. Blocks of many pounds weight have been raised from these workings.

Molybdate of iron is suggested as the base of a microcrystalline submicaceous apple-green ochre from Grandon's shoot on the Norton. It has a light green streak and its hardness is about 3. Mr. Connah, of the Government Chemical Laboratory, informs me the substance is quite without radioactivity, and that uranium, the presence of which was suspected, is absent. Such ochre has hitherto been regarded as molybdite, and it is possible that it is identical with meymacite, described by Dana as a hydrated tungstic ochre, containing, according to the quoted analyses, at least 6 per cent. iron.

Another mineral containing iron and molybdic acid, probably in combination, is a bright canary yellow, has a foliated lamellar structure, and is internally subfibrous. It was collected at the Norton and at the Trafalgar.

Two of Mr. Dunstan's samples of molybdic ochre examined by the Government Analyst in 1905 contained respectively 31 per cent. and 32 per cent MoO_3. This low percentage may have been due to combined iron, with bismuth and tungstic acid also present.

*Molybdenite** (sulphide of molybdenum) occurs sparingly on Bamford Hill, but it has been won in commercial quantities in the northern and southern mines, quite one-half having been derived from the Sunny Corner. It is found not alone in the central quartz pipes, but also in the surrounding quartz rock,

* By the miner colloquially designated "lig."

and sometimes in the less silicified greisen. Euhedral forms are common in the quartz, but rare in the altered rock. Ordinarily it is found in masses built up of radiating six-sided crystals, which have quartz interfoliated along the faces. Part of a crystal of molybdenite secured at the Northern United is ¾ in. long and ½ in. in greatest diameter. It is a slightly tapered truncated hexagonal pyramid, with strong basal cleavage causing the prism faces to be marked by foliated horizontal striae not by any means perfectly parallel. The basal plane is almost always depressed centrally, and it exhibits a plumose radial structure probably to be ascribed to twinning, the rays being normal to the faces but converging slightly towards the centre of the crystal. Under the magnifying glass it is possible to distinguish rhombohedral cleavage striae, intersecting on the basal plane at angles of about 60 degrees. The molybdenite of Bamford has a blue-black appearance in the mass, but when the light has been reflected more than once from its faces these show as a fine blue. It can be easily scratched with the finger nail, and its black streak on paper has a greenish tinge if but very slight pressure be applied. At Miles shaft on the Haymaker the mineral has lost its leafy structure, presumably owing to crushing during faulting of the ore-body. Pyrite is a constant associate of molybdenite, and bismuth also is often found interfoliated with it. Only exceptionally do molybdenite and wolfram occur in contact, but bismuth is a close associate frequently interlaminated, and pyrite is never altogether absent from the vicinity.

Molybdite (oxide of molybednum) must be a constituent of some of the ochres of Bamford, but it is now known that various molybdates have a bright yellow colour as well as certain oxidation products of tungsten and bismuth ores, and it is unsafe without chemical analysis to attempt to classify them.

Molybdo-tungstate of lime is suspected as the composition of a small specimen obtained at the Evening Star. This was at first thought to be scheelite, but chemical tests have proved the presence of both tungsten and molybdenum with the calcium. The specimen has attached molybdenite, but the portions tested were quite free from that mineral. The substance varies from pinkish to greenish in tint, it is cryptocrystalline cherty with subconchoidal fracture, and its hardness is 4.

Monazite (a phosphate of the rare earths) occurs at the Northern United, but it is extremely rare and only one small specimen was collected. It is a honey yellow aggregate, the grains having perfect cleavage or parting parallel to the basal

plane and slightly less perfect parallel to the ortho-pinacoid. (This agrees with Dana's description but is unusual for Queensland monazite.) Its hardness is rather more than 5. Before the blowpipe it blackens but remains infusible. It is soluble in hydrochloric acid, and ammonia precipitates from the solution a flocculent white precipitate due to the presence of the rare earths.

Opal (hydrous silica) was observed at the Dog in quartz crystal lined vugs—a brown to white porcellanous deposit with mammilated surface and concentric internal structure. The quartz crystals projecting into open cavities elsewhere are often coated with an opaque opaline deposit.

Powellite (molybdate of lime) has been detected at the Ferguson United, and it is likely to occur in the oxidised molybdenum ore at any of the mines. It was observed, however, in greatest quantity at the Dog and at the Sunny Corner. Typically it is a greenish or creamy silky laminated subfibrous mineral pseudomorphous after molybdenite, but it also fills interspaces among adjacent minerals, and minute honey-yellow drusy tetragonal bipyramidal crystals have been thrown down in some places where the leaching of the molybdenite has been more rapid than the deposition of powellite. When massive the mineral can scarcely be distinguished from scheelite except that in its microstructure it is slightly more silky and in parts has distinct lamination. The two minerals have actually been found in contact. The powellite of the Dog is accompanied by much quartz in thin pearly sheets, which must have originally been interlaminated with the molybdenite.*

Pyrite (sulphide of iron) is not to be expected near the surface. In depth, however, it is frequently a companion of molybdenite in both quartz and quartz-rock, and it has been observed in one or two cases associated with wolfram. It is a constant constituent of the deeper vug fillings, wherein also chalcopyrite, blende, bismuthinite, &c., may be met. It occurs both in granular aggregates and euhedrally; but the quantity is never great.

* No suspicion seems to have been entertained by the miners of the presence of molybdenum in this ore, all of which met in sinking has been cast over the dumps. This is undesirable, as the mineral would, in all probability, be readily saleable to molybdenite smelters, for, theoretically, pure powellite contains 72 per cent. molybdic oxide, the equivalent of 80 per cent. molybdenite.

Quartz (oxide of silicon).—The white or grey "spar" of the miners is crystalline vitreous subtranslucent quartz, euhedrally developed in cavities. Exceptionally it has open interspaces and then may contain a little mica. It passes abruptly and yet without any perceptible plane of division into quartz-rock or "bastard spar," and without polarised light it would be impossible often to distinguish granules of quartz from either side of the contact. The spar is the chief source of both wolfram and molybdenite, the former being allotriomorphic or in wedge-shaped stumpy laths and restricted to the solid, the latter more frequently idiomorphic and mostly in cavities.

The "spar" is characterised by numerous cavities or vugs of all shapes and sizes. They vary from a few inches to many feet in diameter, and are mostly elongated with the major axis of the pipe. Usually they contain quartz crystals, which in some places show evidence of three stages of growth, as at the Dog, where large, clear, glassy prisms and pyramids are covered by an opaque white coat, superimposed on which are rosettes of much smaller radiating aggregates. Elsewhere the crystals are cloudy in the central part and perhaps darkened towards the exterior. Cairngorm is rare and inclusions are not common but flakes of molybdenite have been observed within glassy prisms. Drusy crystals of a second or third generation were observed filling cracks in the limonite of one of the Morning Star Extended vugs, and at the Rose of Denmark they were found coating blende. In many of the vugs the quartz crystals are embedded in kaolin, which is presumably the residuum in situ of pegmatitic felspar. These crystals are mostly distorted, apparent flattening being common. Some of the crystals are taped through the oscillatory combination of successive rhombohedra and prisms. They are terminated by pyramids with the r rhombohedron predominating over the z rhombohedron, and the oblique bases exhibit crystal facetting. Quartz crystals have also been found in the vugs embedded in sulphides, in fluor and even in a still more recent siliceous cement. The most remarkable form of quartz observed was that occupying casts of the molybdenite, this being pearly, subfibrous, and laminated, and only with care to be distinguished from the accompanying powellite, than which it is slightly whiter, and perhaps more translucent. A small fragment of a purplish-red vitreous subconchoidal opaque jasperoid was given me as from Agnew's shaft at the Sunny Corner. This under the magnifying glass is seen to be traversed in all directions by minute tubes (1/200 in. in diameter). These are lined with hyalite, which also forms a thin

film in all cavities between the jasper and the attached minerals, these last including scheelite.

Scheelite (tungstate of lime) occurs at Bamford only as a secondary mineral after wolfram and felspar. It is assumed that the lime has been derived from lime-soda-felspar of the granite, but that the tungstic acid came from wolfram may be easily shown by the gradual transition for scheelite in the outer exposed parts to wolfram in the interior of many specimens. Much of the wolfram shipped, especially that high in tungstic acid, contains scheelite coating cleavages and cracks, and such often has a distinctly greyish tinge. Even where there is no gradual transition the adjacent wolfram is usually in a friable and partly leached condition. The mineral is mostly restricted to cavities, and in the vugs is frequently found in bipyramidal tetragonal crystals. These are never brightly coloured, being cream tinted to black, with often a sharp plane of separation between tints and that not an optical plane. Some groups are built up of numerous over-lapping smaller crystals with a cup-in-cup structure. A particularly beautiful specimen, from one of the Rose of Denmark vugs, consisted of a loosely compacted mass of more or less distorted bipyramidal crystals of translucent white scheelite, the individuals being 1/30 to ¼ in. in length. These are slightly stained in parts by yellow ochre, and they are attached to a fragment of friable wolfram. Among the crystals are a few hexagonal flakes of muscovite, 1/10 in. in diameter and 1/40 in. thick. An analysis of a sample of Bamford scheelite collected in 1905 by Mr. Dunstan was reported by the Government Analyst to contain—

Tungstic acids ..	..	=	52·2 %
Lime ..	..	=	12·2 %

This may have been an unconcentrated sample, but it is more than likely that molybdic acid was present in combination. (See Molybdo-Tungstate of Lime.)

Stolzite (tungstate of lead) is possibly a constituent of the vug fillings of the Northern United, where both lead and tungstic acid are present. A heavy yellow adamantine crystalline aggregate is found there with associated double pyramids strung one on top of another across cavities, but uncertainty is caused by the known presence of scheelite, also crystallised.

Sulphides.—The increase with depth in the proportion of sulphides other than that of molybdum, elsewhere referred to, is well exemplified in the case of the Northern United, in the upper

levels of which sulphides are absent. As depth is attained, however, the sulphides appear in increasing quantity, particularly in vugs. Already the sulphides of iron, copper, lead, and zinc have been noted.

In the main workings of the Northern United, galena was first met at a depth of 135 ft. It there filled a small vug (9 in. long by 3 in. across) in quartz. Below that none was found for 55 ft., when it again showed with blende in a large vug, associated with molybdenite and a yellowish crystalline mud probably of the nature of chillagite, the tungsto-molybdate of lead.

The Rose of Queensland is another case in point, for below 50 ft. depth wolfram has given place to bismuth-bearing galena very rich in silver—a high silver content being characteristic of these greisen sulphides.

As affecting the paragenesis of the minerals, it may be mentioned that on the Rose of Denmark quartz is found crystallised on blende, and that subsequently crystals of fluor have been deposited on the quartz, and these include needles of bismuthinite. A thin film of pyrite covering the fluor crystals is probably secondary.

Tourmaline (a hydrous boro-silicate of alumina, iron, &c.) in minute acicular brownish-green crystals is thought to have been observed on the Two Jacks but it is conspicuously absent elsewhere from the ore deposits of Bamford.

Wolframite (tungstate of iron and manganese) is commonly known and referred to as wolfram. It is a heavy jet black mineral with resinous or adamantine lustre. Though in one case besides the prism faces both ortho- and clino-domes were observed, it seldom occurs crystallised at Bamford, being usually in coarse wedge- or lozenge-shaped hypidimorphic laths, commonly radiated and exhibiting multiple twinning. It possesses a parting parallel to the clinodome and two cleavages, of which the one with splendant lustre is parallel to the clinopinacoid, the other being parallel to the orthopinacoid. Its hardness is 5, its streak brown, and its fracture is uneven. It is not apppreciably magnetic. Exceptionally the wolfram has a brilliant tarnish, and it is then known as peacock ore. This is exceedingly friable and has probably been subjected to leaching, continuation of which would reduce it to the dull wad-like earth found in the upper levels.

The greater part of the wolfram mined comes from the "spar," but a little is found as small laths in the surrounding quartz-rock; and some residual from pegmatite occurs in vugs, where also in extremely rare cases it appears to have been deposited as a secondary mineral on crystallised quartz (cf. the Northern United).

Wolfram seldom contains inclusions. It is sometimes veined with quartz, but only as an extreme rarity do quartz crystals penetrate it. At the Trafalgar it is intercrystallised with quartz and includes skeletal crystals of felspar. Molybdenite is the only mineral at all commonly found in the wolfram, and even then not plentifully. Acicular crystals of bismuth have been observed piercing wolfram at the Haymaker and at the Morning Star Extended, where the rods lie parallel to the ortho-axis. Pyrite sometimes and scheelite frequently occur as secondary associates, the latter being an oxidation product of the wolfram.

The wolfram of Bamford has always enjoyed a good reputation on the market, the average tungstic acid content of shipments seldom falling much below 70 per cent. Many assays are quoted

Fig. 5.—Wolfram in Quartz, Ferguson United.

by the claim holders of small parcels running 72 per cent. and over; but, on the other hand, some parcels have been carelessly cleaned and corresponding low percentages could be instanced.

The grade of the bagged ore varies from claim to claim, depending on the mineral associations and on the care taken in concentration. In 1905 a sample of wolfram concentrate was analysed by the Government Analyst, who gave the following return:—

WO_3=73·0 %; Mn=6·05 %; and Fe=11·00 %. Total, 90·05 %.

This may be written—

WO_3=73·0 %; MnO=7·81 %; and FeO=14·15 %. Total, 94·96%.

Recalculating, we get for the hypothetical pure iron-manganese tungstate—

WO_3=76·87 %; MnO=8 23 %; and FeO=14·90 % Total, 100·00 %.

and the molecular ratios work out as approximately 3 : 1 : 2. Thus the chemical formula may be written—

(2 FeO. MnO). WO_3,

and the mineral is still to be regarded as wolframite, rather nearer ferberite than hübnerite.[1]

[1] Mount Carbine wolframite has been already shown to correspond to the formula—(3 FeO. MnO). WO_3. See Queensland Government Mining Journal, Feb., 1913, p. 70.

MINING PROPERTIES.

In the earlier days of the rush there seems to have been little respect for law and order, all formalities of pegging out being waived, for every piece of unworked ground was regarded as public property. On some of the richest and shallowest shoad ground—as, for instance, Emily Hill—scores of men were at work on a very small area. With the working out of the richest patches and the thinning of the population, the pegging out of claims became a necessary preliminary to any sinking, but the miner long successfully resisted all attempts at leasing, with its attendant introduction of outside capital. In due course, however, leases were granted and most of the tenures are now in this form. This last change has not proved altogether justifiable, for, while much land has been locked up, the deposits are not exploited on any larger scale than would have been the case if still held under claims.

At the time of my visit, twelve leases were in force besides seven claims. These are tabulated below in order from north to south :—

CLAIMS.	LEASES.
Ballarat	
Trafalgar	
	Northern United
	Rollinson
	Ferguson United
	Osborn United
Gillian and Bridge	
	Norton
	Gray
	Haymaker
	Marseillaise
Hit-or-Miss	
Evening Star	Davis United
	Morning Star Extended
Southern Cross	
Peter's	
	Sunny Corner
	Dog

These are shown on the accompanying geological map, whereon are marked also all workings examined. These last were distinguishable on the original (which was drawn on a

scale of four chains to an inch), but the reduction imposed by the space limits of the "Mining Journal" has, I fear, been too much for their clear reproduction.

Only three underground plans will be found in the following pages. They are on a uniform scale of 60 ft. to an inch, but they also have suffered through excessive reduction.

Adaval.

The old Adaval workings are just below the brow of Bamford Hill, at the south-western end of the main run of productive ground. The quartz-rock and greisen in which the metalliferous pipes are enclosed are separated from the intruded porphyry by unaltered granite. The pipes are small at the surface; but the quartz carries, besides wolfram, magnetite, and molybdenite, an occasional speck of native bismuth; and the presence of abundant limonite denotes that pyrite will be found below the oxidised zone. It is estimated that 10 tons of wolfram have been recovered from the main workings (*fide*-Dangaard), but though molybdenite would seem to have been fairly plentiful it is not known that any has been shipped.

The main opencut proves a width of 20 ft. of silicified greisen in which a shaft has been sunk 100 ft., the first 40 ft. being vertical, the remainder underlying with no regularity to the north-west (?). (This is now inaccessible.)

Other old shallow workings lie a few chains to the west. These are on quartz pipes in granite country with but little greisenisation. The quartz on the dumps carries a little molybdenite and also needles of actinolite.

A1.

Included in Marseillaise.

Ballarat.

The Ballarat, on Rocky Gully, is the north-easternmost of the productive mines of Bamford.

The upper, now inaccessible, 30-ft. shaft is in greisen having disseminated pyrite with the quartz leaders in the bottom. It is understood that the shaft was sunk on one of five small pipes separated by a few feet of barren country. One of the 50-ton dumps has been roughly re-treated by the present holder for a yield of—

$\frac{17}{20}$ ton molybdenite
$\frac{7}{20}$ ton wolfram
1 quarter bismuthite and bismuthinite

The bottom shaft is 50 ft. deep, and underlies steeply towards the porphyry. The dump is being roughly retreated, and thus far 100 tons has yielded—

$\frac{6}{20}$ ton molybdenite
$\frac{1}{20}$ ton wolfram

In both the above cases the mineral has been recovered from the fines by sieving and jigging, no attempt being made to treat the coarse.

Among the observations of special interest made here may be mentioned that of the occurrence of wolfram, apparently a primary constituent, in unaltered granite. One specimen was collected to illustrate in miniature the process of mineralisation following the solidification of the magma and the concurrent

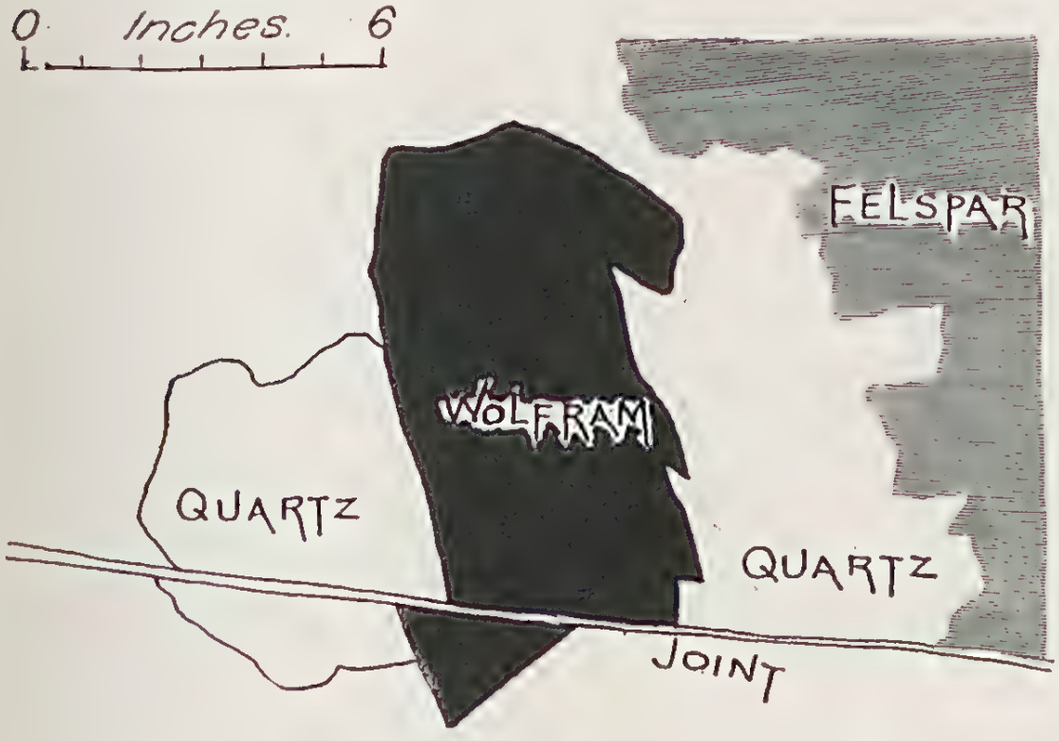


Fig. 6.—Primary Wolfram faulted by joint, X4, Ballarat.

expulsion, concentration, and precipitation of the mineralisers in trap vugs. In this hand specimen we find a central mass of crystalline quartz containing prisms of wolfram, flakes of molybdenite, and books of muscovite. Surrounding this is a thin distinctly graphophyric zone, which like the ore-bearing quartz has crystallised from the residual mother-liquor.

Cornishman.

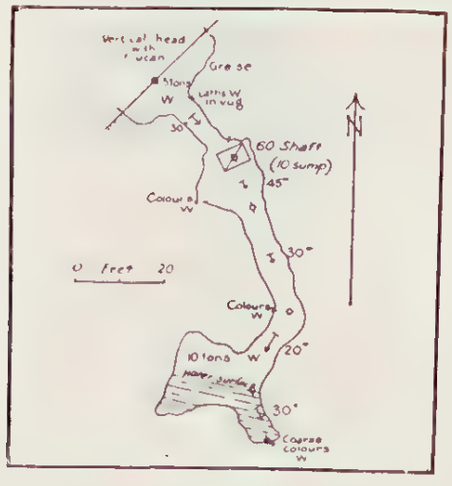
The Cornishman abandoned workings are on the slopes of Bamford Hill, just outside the south-western corner of the Extended.

The quartz pipe, which dips 1 in 1 to the south-west, was followed to a depth of 50 ft. for a small yield of wolfram (say, 1 ton) and bismuth (say, 3 cwt.). The bismuth here as elsewhere on the field is associated with a little molybdenite, to save which no attempt has been made. Magnetite also occurs filling the interspaces in crystalline quartz.

Davis United.

The Davis United, on the eastern fall of Bamford Hill, has been a good producer in its northern part, near the rich ground of the Haymaker and Hit or Miss. In 1909 the lease was purchased by the owners of the Haymaker, for the better working of that holding by adit. The production during the same year is given as 10 tons.

With the object of intersecting one of the many pipes that on the Haymaker dip towards this ground, a shaft was some years ago sunk, and at a depth of 60 ft. struck ore—wolfram-bearing quartz. The full diameter of the pipe has not been proved, but the wolfram-bearing portion, 4 ft. to 20 ft. across, has been followed upwards for 25 ft. and downwards for 70 ft. at an average angle of 30 degrees. The metal-bearing quartz is bluish in tint, and vugs are numerous in it. The upper stope is limited by a vertical head lined with flucan, which is looked on as a good indication, and certainly near the head the ore was above the average in grade. There was 12 ft. of water in the



(*Plane of underlie.*)

DAVIS UNITED.

PLAN 1.

sink at the time of my inspection, but it is understood that there are coarse colours showing in the face. Coarse crystal laths (up to 2 in. long) were seen at three points, and the possibility of the existence of large quantities of low-grade milling stone

surrounding the stopes would seem to be worth looking into. The only country rock showing is the greisen met near the top of the stope. This dips 1 in 1 under the pipe.

It is stated that from the underlie below the shaft a total of 10 tons of wolfram was won, but for such a large production remarkably little exploratory work has been carried out. The stope must have averaged about 3½ per cent. wolfram, and the miners' assumption that the surrounding quartz will carry ½ per cent. is not beyond all possibility. The stope above the shaft intersection yielded 15 tons of wolfram, a rather better return than from below.

Dog.

The Dog lease, on Bamford Creek, marks the south-western extremity of the productive ground, the porphyry of the Razor Edge covering any deposits beyond it, the lease being situate on the contact of granite and porphyry.

Many leaders have been located during the operation of surfacing on the granite country, but the chief underground workings, now caved in, were on two flat-lying pipes of quartz, 6 to 8 ft. in diameter, and these yielded, besides wolfram, bismuth, and molybdenite, much polar magnetite. One of the biggest vugs of this field was met in the 60-ft. vertical shaft. This was 25 ft. long, filled with "rubbish," probably kaolin and quartz crystals more or less recemented by deposition of secondary silica. There was much pyrite and some crystal colours of molybdenite. Among the rejected material on the dumps is the peculiar silky oxidation product of molybdenite known as powellite.

The total production of these deposits is an unknown quantity, but it is understood that from the main underlie shaft there was won 15 tons wolfram and 3 tons molybdenite.

Emily.

A large amount of surfacing and opencut work was carried out by the prospectors during 1903 on the siliceous greisen of the Emily Knob, and it is estimated that a recovery of quite 50 tons of wolfram must have been effected; but only thin leaders were located, offering no inducement to deep sinkers. One adit was put in 70 ft., from above Gillian and Bridge's copper shaft and appears to have passed from the greisen into decomposed granite without revealing any ore.

Enright and Thompson.

Numerous irregular and mostly small bodies of quartz and siliceous greisen occur in the granite neck between the porphyries

of Sunny Corner Hill and the Razor Edge. Enright and Thompson's caved shaft is in greisen carrying a little molybdenite and traces of wolfram. The workings were not extensive.

Evening Star.

The Evening Star is on the eastern slope of Bamford Hill, between the main mass of porphyry and a small outlier of the same, and comes within the richer contact country which slopes with the hillside. Conditions are thus favourable for exploitation by deep adit, but, owing to the uncertain pitch of the pipes, the claim holder prefers to follow the ore from shallow adits.

The workings at the top end of the claim are shallow. In them it would seem that the wolfram occurred without any regularity in the more siliceous parts of a shoot of siliceous greisen in decomposed granite. In the deeper workings pipes of quartz have been intersected and stoped. The quartz is bluish

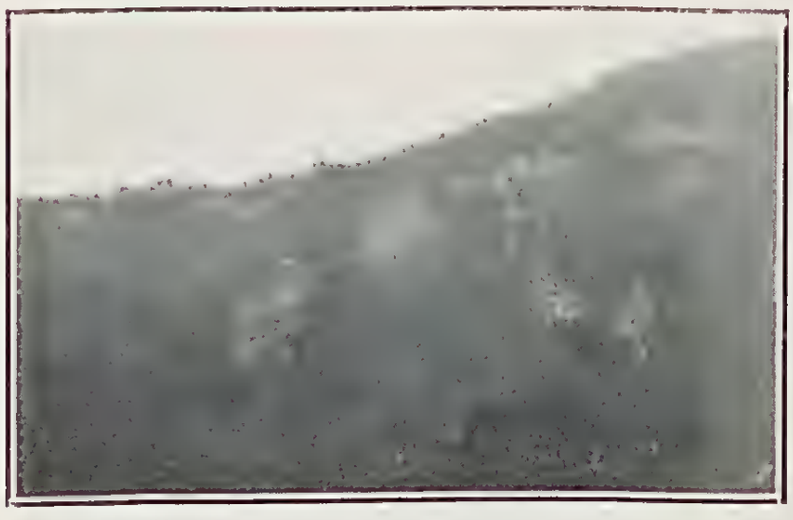


PHOTO. 3.—EVENING STAR.

WITH HAYMAKER ABOVE ON THE RIGHT AND EXTENDED ON THE RIDGE IN THE DISTANCE. VIEWED FROM THE EAST-SOUTH-EAST.

and crystalline, and through it there are scattered bunches of molybdenite, as much as 5 in. in diameter, besides sporadic hexagonal flakes of the same mineral. There is also some pyrite and patches of chloritic material as well as a little native bismuth and bismuthinite.

A body of quartz 5 to 10 ft. in diameter was stoped out above the adit, but this on the adit level split up into a number of thin leaders. The iron-stained hanging-wall joint was followed for 20 ft., on its dip of 55° to S. 30° E. A vertical winze was then dropped and a new body of quartz, dipping 70° to the east,

was intersected. This, in the bottom 40 ft. below the adit, is 2 ft. 6 in. by 6 ft. in section and carries 2 per cent. molybdenite. The surrounding silicified greisen also carries a little molybdenite and bismuth.

From Mr. Rowan, tributing on the claim, it was learnt that a total of 60 tons of wolfram has been won from the claim, with 4 or 5 tons of molybdenite.

Ferguson United.

The Ferguson United, on Rocky Creek, though idle during my visit, has been a good producer. It was one of the principle claims in 1906, and the yield for August in that year was over 7 tons, this coming from a vein of massive wolfram 4 in. wide and 12 ft. in length across the face. The shoad ground in the southern corner is said to have been the richest on the field, but the greater part of the holding has been surfaced. There are one large and three small open cuts besides three shafts.

In *Knox's open cut* greisen and quartz-rock lie in floors dipping 1 in 1 eastwards—*i.e.*, towards the porphyry, and in these rocks occur irregular pipes of crystalline quartz. The quartz in one part of the cut is extremely coarsely crystalline, the crystal masses being as much as 3 ft. in length. These quartz pipes carry coarse colours of wolfram, some of which gives evidence, in its contained limonite and ochre, of having suffered decomposition. A little molybdenite also is present.

Knox and Devery's Adit, near the top of the cut, struck a rich patch of quartz within 10 ft. of the surface. This yielded 1½ ton wolfram.

A good deal of stoping has been done in the footwall portion of a great body of quartz at the *Top adit,* which is connected by an underlie with the southern adit. The quartz is 20 ft. thick, and as wolfram is distributed, it has been marked out for opencast operations.

The *Southern Adit,* in front of and below this cut, passed through porphyry, but at the end is a body of quartz, 15 ft. across, which is said to have been followed down by the underlying winze, now flooded, for 80 ft. before it cut off against the porphyry.

The *Main adit* runs in across the contact into the quartz-rock, in which two main shoots of white quartz carrying wolfram were located. The tunnel shaft 20 ft. from the mouth of the

adit is 43 ft. deep, the upper part vertical, the lower dipping with the contact, which is but a few feet away. The quartz shoot was up to 10 ft. in diameter, and besides disseminations in the solid it carried crystallised wolfram and a little scheelite in vugs. One rich patch, yielding 3 tons wolfram, was got 20 ft. below the adit, where a branch pipe came in.

The inner shoot worked from the surface was followed on an underlie of 1 in 1 for 30 ft. In one place it was 10 ft. across, but usually it had no defined boundaries. The quartz was coarsely crystalline and rich in wolfram, accompanied by a little bismuthinite. Above the underlie there may still be seen an 18-in. band of white clay containing crystals of quartz up to 3 in. long and 2 in. in diameter, and in places plentiful wolfram. It would seem to be a kaolinised dyke of pegmatite. The yield from the underlie was 16 tons.

PHOTO. 4.—FERGUSON UNITED.

WITH ROSE OF DENMARK ON RIGHT AND BAMFORD HILL ON LEFT FROM ACROSS ROCKY CREEK.

Between the tunnel shaft and the underlie a flat shoot has been located and followed on to the porphyry contact, here dipping westward—the opposite to the normal. The quartz is white and crystalline but gradually shades outwards into siliceous greisen and that into micaceous greisen. It carries wolfram with a trace of molybdenite, and in vugs a little pyrite occurs.

Above the adit several patches of quartz rich in wolfram were found by following a strong clay seam to Wallace's workings. These last are on a pipe, averaging 5 ft. in diameter, of crystalline quartz carrying wolfram with, in the shallow ground, quite 4 per cent. bismuth. The richest bunches of ore have been located where clay heads come down in the flatly jointed greisen; and it is almost certain that the pipe itself follows joint intersections, though the joints themselves are no longer open. The trend of the pipe is at first southwards at 1 in 1, but at Wallace's 20-ft. shaft it bends suddenly to the west, after a short distance it changes again to the south (with dip decreased to 30°), and below that it shoots to the east-north-east, then east, and lastly south-south-east to its termination on the porphyry contact, which still dips abnormally to the westwards. Numerous spurs are given off from the pipe, any of which may be worth following and may be more permanent and productive than that worked.

It is proposed to sink a vertical shaft to the dip of the southern workings to pick up the continuation of the shoots hitherto underhand stoped.

Generally then the shoots worked are indefinite in form and trend, discontinuous, and liable to branch. This is probably due to excessive jointing in the contact zone of the granite having allowed of the spreading of the ore bringers, with consequent general greisenisation and silicification. The occurrence of metal-bearing quartz actually on the contact surface of the porphyry at the Ferguson United is to be contrasted with the occurrences on Bamford Hill proper, where the productive greisen is some distance away from the porphyry.

Young's shaft has been sunk on the underlie to the boundary of the claim 100 ft. below the surface. The pipe yielded besides wolfram (2 tons), wolfram-bismuth (7/20 ton), a larger quantity than usual of molybdenite (1 5/20 ton).

Mr. Dow, one of the proprietors of the lease, estimates that the Ferguson United has produced 200 tons wolfram and 6/20 tons bismuth, but not more than 1 7/20 tons molybdenite.

Gillian and Bridge.

The greisen of the Emily Knob, which is included in this claim, has been worked open cast to shallow depths over an area of several acres, but the present productive workings are in a gully at the head of Rocky Creek.

An adit here runs in across the flat-lying contact of the porphyry and greisen, in the latter of which two pipes have been discovered. One of these was followed from the surface to a depth of 50 ft. (*i.e.*, to near the end of the adit) for a yield of 3 tons of wolfram, exclusive of any won in the early days by open cutting. In the face there is now exposed 1 to 3 ft. of ironstained cavernous crystalline quartz, barren of metallic metal but promising and worth following.

The other pipe was discovered in following a thread of molybdenite that crossed the adit, and a shaft was then sunk from the surface intersecting it immediately below the porphyry at 50 ft. depth and continuing on it to a total of 90 ft. in quartz-rock. Near the porphyry the grade must have been high for the prospectors during a period of three months recovered 4 cwt. wolfram and 1 cwt. molybdenite per week, a total of 3 tons of concentrates. The bottom of the shaft is in blue and white quartz and pyritic chlorite. Bismuth is disseminated in the blue quartz, and molybdenite in the chlorite. Wolfram crystals up to 2 in. in length occur in the white quartz, where also a little molybdenite is showing.

PHOTO. 5.—GILLIAN AND BRIDGE
FROM THE EAST, WITH EMILY HILL IN THE BACKGROUND.

The molybdenite obtained from these workings is crystallised in quartz, individual crystals being 1½in. in diameter and radiating in structure. Its oxidation has given rise to the rare

molybdate of molybdenum, ilsemannite, which occurs as a blue incrustation on and among the quartz crystals.

A third small pipe of molybdenite was followed for 20 ft. below the adit, where it is said to have been lost in a pyritic formation.

This mine is to be singled out also because of the discovery of comparatively high grade copper lode material in the vicinity of one of the wolfram-bearing quartz-pipes. The workings were not made accessible to me but it is understood that the pipe is 2 ft. in diameter and has been followed down from the surface beneath the gently inclined cap of porphyry, passing over a mass of cupriferous chlorite at 42 ft. depth. This formation was subsequently sunk on, and at 80 ft. vertical depth an 8-in. pyritic seam was found to dip away from the shaft towards the west, whereas the quartz pipe, 2 ft. by 8 ft. in section, continues to the eastwards. The pyritic ore at the brace contains in addition to massive chalcopyrite some zinc blende and crystallised pyrite, as well as a little molybdenite. A parcel of 3 17/20 tons of the hand-picked ore was sent to Chillagoe in 1907. This contained

Cu = 16% ; Au = 1½dwt[1]. Ag = 10oz[1] ; and Bi = ? [2].

Mr. Hedley reports the quartz yielded Burgess:

1 ton wolfram and $1\frac{19}{20}$ ton molybdenite.

Several shallow shafts have been sunk along the southern boundary, but the yields were small.

The total production of the claim is an unknown quantity, but it can scarcely have been less than 100 tons wolfram. An output of 8 14/20 tons wolfram and 3 2/20 tons molybdenite has been accounted for in recent years alone.

Gray.

The Gray is on the north-eastern shoulder of Bamford Hill, and adjoins the Haymaker. It has been well surfaced, with very satisfactory results, much of the shallow ground having yielded wolfram at the rate of ½ cwt. to 1 cwt. per man per day; and some sinking has been done on three main pipes and their branches.

Grandon's, on the northern boundary, cropped as an ironstone blow, but the quartz pipe below averaged 4 ft. in diameter and dipped 30 degrees to 50 degrees eastwards (towards the porphyry) to the boundary at 40 ft. depth. Allowing for one

[1] Per ton. [2] Sufficient to ruin the parcel as copper ore.

10 ft. blank between 25 and 35 ft. on the underlie, we must conclude that the quartz was thickly studded with wolfram, for the yield from above the boundary was 16 tons. The country is quartz-rock, but in the stopes there is much soft mica-rock, some of which carries wolfram.

Two branches of *Johnson's* pipe cropped near the centre of the lease. One dipped eastwards and the other southwards at an angle of 30 degrees to their junction, below which the pitch was to the east, the angle increasing to 40 degrees. The conspicuously flat-jointed country is greisenised granite passing in places into kaolinised granite, a change usually accompanied by an increase in the proportion of wolfram. The greisenised granite gradually shades off into greisen, which becomes more and more siliceous till the core or pipe of quartz is reached. The pipe has been followed to a vertical depth of 50 ft., where there are showing only small areas of white quartz with bluish quartz-rock above and greisen below a flatly inclined joint along which the country is decomposed through a thickness of 6 in. to a foot. The wolfram recovered from these workings amounted to 24 tons, of which 7 tons came from a depth of 50 ft.

The old shallow shafts (*Gray's, Inne's, Proctor's,* &c.) on the south-western side of the lease are in flat-jointed quartz-rock, wherein crystalline quartz carrying wolfram has been met in bunches. In Inne's shaft, the deepest, pyrite appeared with water towards the bottom and work therefore ceased, though conditions were regarded as favourable for the occurrence of molybdenite, of which traces are noticeable in the dumps. Some 1½ ton of shoad bismuth was got on the surface.

The lease's total production of wolfram is calculated by Mr. Gouge as 70 tons, and as over 30 tons came from Johnson's workings and 20 tons from Grandon's, this does not seem to be an over estimate.

Haymaker.

The Haymaker, comprising as it does the crown of Bamford Hill, is the highest lease on the field. It has also been the most prolific. The year 1910 was one of the most strenuous, there being then six tributers at work besides the owners, and for a time the mine turned out wolfram at the rate of 2 or 3 tons per week. The older miners tell of the great blocks of wolfram that lay scattered over the ground in the days when a market could not be found for the material. We have now no means of

ascertaining the total wolfram shipped from here, but Mr. Gouge has kept the following record since he became a shareholder:—

—	W.	Bi.	Bi.-W.	Mo.
	Tons.	Tons.	Tons.	Tons.
Prior to 1907	40	..	..	..
1907-1908 (total)	$51\frac{19}{20}$	..	..	..
1909 (total)	$31\frac{19}{20}$	$2\frac{3}{20}$	$5\frac{3}{20}$	..
1910 (total)	7	..	..	..
1911 (total)	$4\frac{19}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	..
1912 (May)	$1\frac{10}{20}$	$\frac{1}{20}$	..	..
Tributers, 1907-1912 (May)	54	1	..	4
Total to May, 1912	$191\frac{7}{20}$	$3\frac{12}{20}$	$5\frac{12}{20}$	4

Mr. Paul Jensen of Lappa Lappa, one of the few of the early mining residents still on the field, informed me that the first parcel of wolfram, 5 tons in all, was shipped to Sydney in 1896, and realised £9 per ton above expenses.

The surface has now been well worked over and many of the pipe sources have been uncovered. A not inconsiderable amount of opencast work has been undertaken and nine shafts have been sunk.

Freeman, the original holder of this ground (as the Oakvale Surprise claim), opened the *Bismuth Cut* near the top of the hill. He also won 7½ tons of shoad wolfram from the highest point on the ground. Subsequently 2 tons of bismuth carbonate was recovered by re-screening his dumps, some lumps being as large as the fist.

They have on the Haymaker, in *No.* 1 *shaft* and the *main adit,* the largest lode yet discovered at Bamford. This can scarcely be designated a pipe, for, though its whole extent has not yet been proved, the workings show the main mass to be distinctly tabular, 5 to 7 ft. thick and 60 ft. wide. It has been followed on the underlie 120 ft. to the dip, at angles of from 45° to 70°. There are, it is true, branch pipes dropping off from this tabular mass, and these probably mark the channels through which the ore bringers rose from the magma below, to be trapped beneath gently dipping heads or major joints. The lode material consists of bluish quartz-rock, through which run contorted shoots of wolfram and bismuth. On the upper level, the wolfram still showing is much coarser than that at the adit, one "colour" enclosed in blue quartz being a foot long and 3 in. wide. No

rich stone has been found below the adit level, but then the shaft extends only 20 ft. down, and there is much room for prospecting towards the west, where rich stone may reasonably be expected.

Some stoping has been done above the west drive off the adit, but a large amount of stone yet remains to be broken down between it and the upper level off No. 1 shaft. Generally the roof of the adit stope is determined by a flat dipping joint—often having a clay selvage, adjacent to which the quartz carries particularly good values in wolfram and bismuth. The country to the east of the main haulage way is greisen, but the adit is in decomposed granite—that is to say, there is a belt of unaltered granite between the porphyry and mineralised zone.

In the stope above the adit level much white kaolin is found as an infilling between quartz crystals. This may be the result of pneumatolytic action on the felspar of older pegmatite masses, or it may be due merely to weathering.

Mr. Fletcher, one of the leaseholders, informed me that the total yield from the No. 1 workings may be taken as 85 tons of wolfram, averaging over 70 per cent. WO_3. One parcel of a ton assayed 72·5 per cent.

Heyden's Cut, from which 10 tons of wolfram was got, is on the western slope and near the point of the hill. It is said to have been the only opening when the present holders took over the ground. Nuggets of wolfram of up to 7 cwt. came from the surface here. The cut is in siliceous greisen with flat kaolin seams, and it overlies kaolinised granite. From the cut an adit runs eastward into the hill and connects with the top shaft. Some stoping has been done for a yield, it is said, of 3 tons of bismutite, this being, therefore, the best patch on the field. The greisen and kaolin at the inner end of the adit appear to be well worth the prospectors' further attention.

No. 2 pipe has been worked out to a depth of 100 ft., the dip decreasing from 60° near the surface to 45° in the lower part. It was 5 ft. in diameter at the crop, but swelled to 13 or 14 ft. in places below; and it is responsible for a yield of 8 tons wolfram with 2 tons molybdenite and 1 ton bismuth. It is now flooded and inaccessible.

No. 3 pipe underlies 1 in 1 towards the contact. It has been sunk on to a depth of 100 ft. and proved to have an average diameter of 5 ft. Great lumps of wolfram were found on the

surface by the prospectors, and the shaft yielded 7 tons of wolfram with 5 or 6 cwt. molybdenite and a little bismuth. The mullock dumps indicate the presence of some pyrite and from the same it is learnt that the country is greisen.

No. 4 pipe is said to have been 6 to 10 ft. in diameter and to have yielded 2 tons wolfram. The shaft is vertical for 30 ft. and then underlies 1 in 1 towards the contact.

No. 5 pipe, which crops almost on the summit of Bamford Hill, is responsible for the largest patch of wolfram yet found on this field—22 tons of the mineral having been recovered from 20 ft. of sinking. The total yield is given as 27 tons wolfram, 2 tons bismuth-wolfram, and 1½ ton bismuth.

The shaft descends vertically 15 ft. from a small open cut. The shoot, carrying bismuth values only, then pitched off to the east-north-east at an inclination of 1 in 1, gradually widening out to a width of 25 ft. in the bismuth stope. Half-way down a drive was put in to the northwards, proving micaceous greisen with bismuth contents (both metal and carbonate) for 20 ft. from the shaft, besides a little wolfram. Both bismuth and quartz are still showing in the walls of this stope, but the richest ore passed under foot to the east-by-north. This was a greisen-surrounded body of quartz up to 8 ft. in diameter, and for 35 ft. it yielded 1 ton of wolfram per foot of sinking. Clay seams form the roof, but there also shows still much barren ferruginous quartz with crystalline vugs. Below this rich part the shaft was continued 15 ft. in bluish quartz with colours of bismuth carbonate only. The quartz has flat flucan joints like the greisen into which it passes westwards. There are also numerous vugs filled with red clay. The possibility of striking fresh shoots of " metal " always exists in such an ore-body.

From the southern end of the bismuth stope another shoot of ore-bearing quartz pitched east-by-south; and at 40 ft. down an incline of 1 in 1, the face is in bluish quartz with bismuth carbonate values (just below the payable grade). This quartz is intersected by a strong joint filled with clay. Spurs have been worked north and south from the incline; in the latter a 2½-ton lump of wolfram was met, and wolfram and bismutite are still showing in the quartz here. The greisen country is strongly jointed, the dig lined heads dipping flatly. The wolfram from this pipe is said to have assayed 72 per cent. WO_3.

The Little Adit opens out of a large cut above No. 1 shaft. The wolfram, of which 5 tons came from the cut, occurs in

patches in silicified greisen shading into crystalline quartz. The adit, from which no production has yet been recorded, seems to be passing into kaolinised and greisenised granite under the greisen, of which the cut proves a thickness of 18 ft.

No. 6 shaft is in the same zone of flat-jointed greisen as the No. 1 workings. A small shoot was sunk on vertically for 15 ft., when it ran off northwards for 15 ft. and eastwards for 20 ft. at low angles. As the shaft and the cut above it yielded 3 tons of wolfram, some rich stone must have been raised. It is believed that the silicified country surrounding the shaft carries sufficient wolfram to warrant its exploitation by open-cast methods.

Wright and Stoney's open cuts are nearly 30 ft. deep, but are now caving in. These old workings are credited with a yield of 7 or 8 tons of wolfram.

Miles's shaft is on the south-western boundary of the lease. It was sunk during 1911 by a party of tributers to a depth of 80 ft. in quartz-rock shading outwards into decomposed granite.

PHOTO. 6.—BAMFORD HILL AND HAYMAKER.
AS SEEN FROM THE TRIBUTERS' SHAFT, SUNNY CORNER.

The quartz pipe for the first 20 ft. pitched south-west at 70° and then became nearly vertical. In section it was usually flattened, and it had a major diameter of 20 ft. When seen by me in 1911 the tributers were stoping on 12 in. to 2 ft. quartz containing

bunches of molybdenite and wolfram, with much soft pyritic material in the sink. The ore had been found to follow a well marked joint sometimes lined with quartz crystals. Mr. Price, the tributer, informed me subsequently that an earthy greenish chloritic material came in towards the bottom of the shaft, and at the same time the wolfram failed. Miles's shaft has been the most prolific of the Haymaker workings in molybdenite, which mineral was in excess of the associated wolfram. It occurs in coarse nuggety form and has traces of pyrite between the laminæ. One patch of 3 tons was struck at 50 ft. below the surface, and during 1912 the old dumps were turned over and screened for molybdenite fines lost during mining.

Heart.

The Heart was an alluvial claim on the porphyry in Bismuth Gully, the ground worked being a narrow run coming down from the Extended crops. The workings, which are but a few feet deep at most, widen gradually from 10 ft. at the top end to 1 chain on the southern boundary. Water for sluicing is available for a week after heavy rain, and concentration is effected by banjo for a month longer—the holding having thus to lie idle for the greater part of the year. The claimholder is said to have won quite 10 tons of wolfram.

Hit or Miss.

This claim is to the dip of the rich ground on the eastern side of the Haymaker, and it is estimated that 100 tons of wolfram was won from it during the years 1903-1912. In 1907 the owners' profits were at the rate of £6 per week per man. There are four main open cuts and six shafts.

The 5-ft. wolfram-bearing pipe worked in *No. 1* cut was followed by No. 1 shaft to a depth of 40 ft., where the shoot was lost. A little further down, however, at *No. 2* shaft, another obliquely running shoot was worked for a distance of 20 ft., when it also cut out or dipped into the floor. Sinking was continued for 70 ft. in bluish-rock quartz, too poor to pay for wages, till 5 cwt. of bismuth was got 50 ft. down with a small quantity of wolfram. In the face 15 ft. beyond there are only stringers of white quartz in bluish quartz-rock having a little disseminated molybdenite and wolfram. The cost of exploratory work having now become prohibitive, the tributers rose above the wolfram patch on a water-head; and they then drove towards the new vertical shaft to make a connection for ventilation.

The tributers' *1st and 2nd cuts* are in much-jointed silicified greisen, the former with sulphide-stained quartz. These workings do not seem to have given remunerative results.

Cahill's Shaft pipe, from which tributers won fair returns, is in the north-western corner of the claim. It has been followed by opencut and underlie shaft a total distance of more than 100 ft., the dip gradually decreasing from 60° near the surface to 30° and less near the bottom, where there is said to be promising quartz with a little molybdenite and wolfram. No bismuth was got below the opencut. The country is blue quartz-rock.

Leo.

The Leo, on Rocky Creek, south of the Osborn United, is now included in the Gillian and Bridge. The various workings are said to have yielded 10 tons of wolfram and much bismuth, the prospectors having recovered alluvial bismutite at the rate of 2 bags per week during the progress of dry shaking.

Mr. Hedley informed me that some wolfram was found at 50 ft. depth in the *Iron shaft* though at the surface limonite only cropped.

Barrett's cut is said to have yielded 3 tons of wolfram, and from *Short's 30-ft. shaft,* now used as a well, a little bismuth came.

Marseillaise.

The Marseillaise is a large lease at the head of Nuggety Gully, including Moseley's, better known as the A.1 claim. Three shafts have been sunk on it for a very small return, probably not more than 2 tons molybdenite and 1 ton wolfram having been won during the past two years. The greater part of the lease is covered by porphyry, and in the remainder conditions are not altogether desirable, the granite having been insufficiently altered for rich shoots to be expected at the surface. At a depth, however, the well jointed and greisenised zone worked to such advantage on the Haymaker, Davis United, and Hit or Miss, may yet become productive beneath this holding.

Moseley's shoot, the best located, was sunk on with Government aid to a depth of 97 ft. during 1908 and 1909. The pipe is said to have been a very small one and cut out altogether towards the bottom in quartz-rock, exhibiting occasional splashes of molybdenite. Wolfram was got in the upper part of the shaft, and molybdenite in the lower part, the latter associated with sulphides of copper, lead, silver, zinc, and bismuth. A

block of this pyritic ore shown me consists chiefly of cupriferous pyrite with scattered galena, traces of quartz, and some green chloritic mineral. A sample of this ore is reported to have assayed:

Gold = 3 dwt. 19 gr. per ton.
Silver = 18 oz. 1 dwt. per ton.
Copper = 9·8 %.
Lead = 4·6%.

The leaseholder at the time of my visit was sinking in hard, much jointed greisenised granite in the northern part of the lease, and scattered through the rock were small bunches and crystals of wolfram, traces of molybdenite, and some comparatively large masses of pyrite.

Morning Star Extended.

This holding adjoins the Haymaker on the south-west. It is better known as the Morning Star or the Extended, the names of former leases.

It has been one of the premier producers since 1904, and has yielded more bismuth than all the other holdings together—6 or 7 tons. At least 130 tons wolfram has been recovered, but the molybdenite saved was only a few hundredweights.

The old wolfram-bismuth surface workings extend parallel with the contact right across the northern part of the lease from the Davis United and Haymaker, and there are shafts in every part; but the most productive workings are near the centre, where we have a zone of quartz-rock lying parallel with the contact surface of the granite and overlying porphyry. In this zone the wolfram and bismuth occur irregularly in the neighbourhood of flat, well-defined joints; but though there is a multitude of inclined joints, it is doubtful if more than a few of the latter had any connection with the deposition of the minerals, for most of them had probably not developed at the time of differentiation.

From the *Tunnel shaft* and *No.* 1 *adit* two of these flat-lying shoots were worked. These are 6 ft. high and 8 to 10 ft. wide, and 20 ft. apart. A connecting shoot has been discovered adjacent to a master joint at the eastern end of the shoots. From the stope to the west of the tunnel shaft 25 tons wolfram and ½ ton of bismuth was won, but beyond the drive towards No. 2 adit entered barren quartz-rock. A few flakes of molybdenite are to be seen in this ground, but there has been no commercial production of the mineral.

No. 2 cut exposed a shoot of bismuth ore pitching 60° to the north-west. At 30 ft. from the surface the shoot turned over to the north-east and was sunk on for 20 ft. at an angle of 45°. In the bottom, which is believed to be in the vicinity of the western drive from the tunnel shaft, there is very little ore showing.

The *Bismuth cut* was opened on a small shoot of bismuth ore, perhaps an offshoot of that worked in No. 2 cut, which is almost contiguous with it. The shoot was 15 ft. long, 6 ft. wide, and 12 ft. high, and from it was won between 2 and 3 tons of bismuth. A little of the ore left on the side of the cut contains quite 5 per cent. of bismuth-wolfram. The shoot has no distinct walls, nor is there any defined run of ore, the bismuth simply occurring as a filling in the more shattered parts of the quartz-rock. The cut, on being extended northwards along a master joint, met a shoot of wolfram ore, 5 to 8 ft. wide, which was followed for 45 ft. when it was cut off by a dyke of felsite. No bismuth was got here, but 20 tons of wolfram was recovered. The underlying country is quartz-rock, without any special feature such as a master joint to indicate the reason for the existence of the shoot in this position. On driving

PHOTO 7.—MORNING STAR EXTENDED
LOOKING EASTWARDS.

through the felsite, ore was found again, the shoot pitching flatly west-north-westwards along the dyke. The shoot was connected with the surface by a shallow *whip shaft* sunk through decomposing much-jointed granite. The shaft exposed a small pipe of chloritic material containing specular iron ore. There are also irregular bodies of quartz containing molybdenite, scheelite, and traces of chalcopyrite—the last in cracks.

The Bismuth cut and whip shaft yielded in all about 30 tons of wolfram, besides 10 tons got on the cap. The wolfram is glossy black on the cleavages, but slightly ferruginous in old cracks. As marketed, it assays 68 to 69 per cent. WO_3, but picked samples run 72 per cent.

Other shoots have been worked in the shafts to the north of the adit workings, but they were cut off in depth by a felsite dyke, probably a faulted part of that referred to above.

The *new top shaft* sunk in 1912 intersects wolfram-bearing quartz on the opposite side of the dyke and at a depth of 35 ft. The shaft underlies 1 in 1 westwards, and at the time of visit had reached a depth of 75 ft. It seems to have passed out of the shoot first intersected into another coming down from the surface. This is overlain by greisen, and there is probably quartz-rock below it. The face of crystalline quartz is estimated to average 2 per cent. molybdenite-bismuth, the minerals occurring in nests as much as 4 in. across; but there are traces of chalcopyrite. As having come from this place, Mr. Dangaard, one of the shareholders, gave me a most interesting specimen of wolfram penetrated by needles of metallic bismuth. The lower part of the shoot is practically barren, and has been left as a floor; but the face exhibits a number of open crystal-lined vugs. The yield is given as 5 tons wolfram, 5/20 ton molybdenite, and 4/20 ton bismuth.

Graham's shaft, now abandoned, in the south-western corner of the lease is probably 50 ft. deep. It was sunk, with a steep dip north-westwards, on a 6-ft. pipe of quartz carrying molybdenite and wolfram.

Miles' shaft and opencuts are in the north-eastern corner. The shaft is on a fine shoot of white quartz, yet the product of 40 ft. of sinking and driving was but a few bags of wolfram. The yield from the cuts was probably considerable, but has not been recorded.

Northern United.

The Northern United, the northernmost of the leases on Rocky Creek, is credited with a production of between 80 and 100 tons of wolfram, and is to be ranked among the best holdings of the field, having been continuously developed since 1905 by an average of five men. The wolfram, moreover, is of a good class, and the concentrate as marketed averages 70 per cent. (*i.e.*, 69 per cent. to 71½ per cent.) tungstic acid.

PHOTO. 8.—NORTHERN UNITED, WITH ROLLINSON ON LEFT. AS SEEN FROM ACROSS ROCKY CREEK.

Mr. A. Quill has records of output during recent years as tabulated below:—

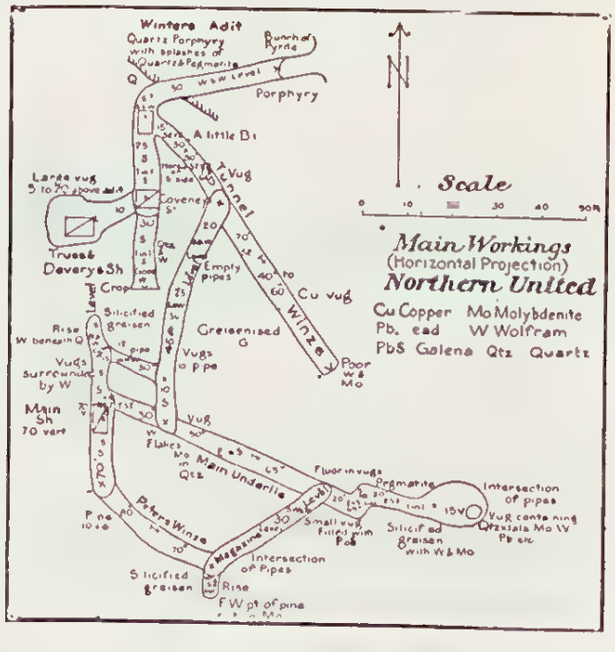
1909—19	tons wolfram;	and	$1\frac{15}{20}$	tons molybdenite.
1910— 9	„	„ ;	„	$1\frac{12}{20}$	„	„
1911—$16\frac{11}{20}$	„	„ ;	„	$1\frac{14.5}{20}$	„	„
1912—	..			$1\frac{3.5}{20}$	„	„

There are three chief sets of workings in the central and southern parts of the lease, those in the north being of uncertain standing. Unusual facilities are available in this mine for the making of observations—on the occurrence of pipes, on the occurrence of vugs (both in the quartz pipes and in the enclosing altered country), on the increase in sulphides in depth and their preference for vugs as a habitat, and on the tendency of molybdenite to concentrate in the under side of the pipe.

The *main whip shaft* on the Rollinson boundary is connected with Winter's adit and Truss and Devey's shaft. Several more or less isolated pipes in the close vicinity of the contact have been exploited, but to describe them in detail would be tedious. The last worked was that of Truss and Devery, above the adit. In driving towards this, another richer shoot was met and followed by winze on the underlie a total distance of 145 ft. An indefinite horizontal shoot was followed off this and led to another steeply dipping pipe. The main whip shaft was sunk for the purpose of improving the ventilation, and by it still another pipe was revealed. The greatest of the shoots is that

PHOTO. 9.—NORTHERN UNITED.
MAIN SHAFT FROM THE SOUTH-EAST.

in the tunnel winze, a width of 20 ft. of quartz having there been broken down without meeting the hanging wall. This is above the 45-ft. level, below which the pipe contracted to less than 5 ft. diameter, which is more nearly the average of the other ore-bodies.



PLAN 2.

The shoot followed on the underlie below the vertical section of the main shaft has been persistent and productive to

a depth of 190 ft.; but near the bottom it contracts much, and in the sink has given place to a line of vugs below its intersection by a cross shoot. A rich strike of wolfram was made just below the intersection, 15 tons being won from the chamber above the sink, 20 ft. high and 15 to 20 ft. in diameter, and there is still a good sprinkling of the mineral in the surrounding quartz-rock. In the sink a great vug had just been broken into. This was still under a foot of water, but grab samples of the filling material were secured. These contain, besides abundant quartz crystals, an earthy crystalline mud, including some molybdenite, galena, and blende. This mud, after removal of visible sulphides, was found by the Government Analyst to contain—

Pb	.. =	40·3 %	
Bi	.. =	Nil.	Also—
MO_3	.. =	29·8 %	Au = tr. (less than 9 gr. per ton)
WO_3	.. =	9·4 %	Ag = 3 oz 2 dwt. per ton.
		79.5	

The surrounding country is quartz-rock, with some specks of biotite and small irregularly shaped masses of quartz carrying

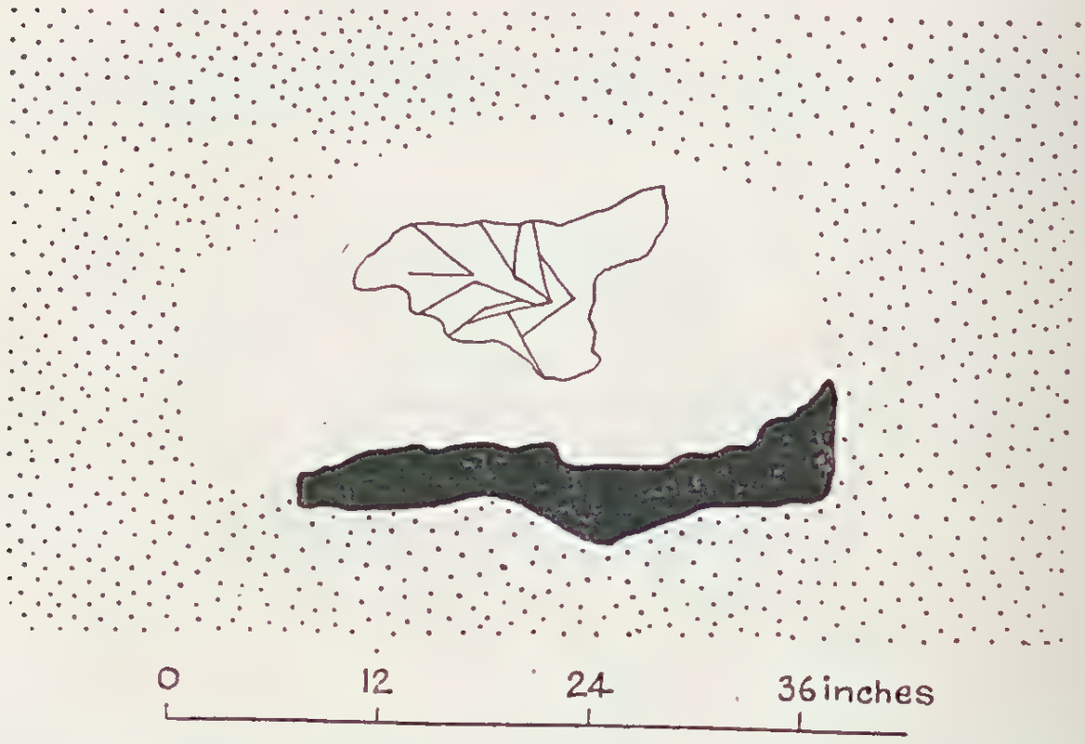


Fig. 7.—Pipe of Crystalline Quartz with Vug packed with Quartz Crystals and basal layer of Molybdenite.
Tunnel winze, 45-ft. level, Northern United.

colours of wolfram up to 6 in. long and 2 in. wide, and in the more vuggy parts showing molybdenite. Small patches of kaolin in the quartz are probably the remains of felspar inclusions.

The wolfram in the main workings is fairly coarse, and it has been observed that where the crystalline quartz includes horses of the granular quartz-rock, these latter are apt to be surrounded by wolfram, such being also the case with one of the smaller vugs. (*See* the stope, 70-ft. level, main shaft.) The molybdenite, too, though the individual crystals are seldom more than 1 in. in diameter, tends to occur in bunches with a preference for the under part of the pipe. One of the best cases observed by me was in the rise off Peter's winze, where the quartz pipe was 10 to 12 ft. long and 3 to 5 ft. wide. Within 6 in. of the underlying greisen almost the whole of the molybdenite has collected, there being but few flakes of the mineral in the main body of the quartz and in the footwall country. The molybdenite is of high grade, being very solid, with no inclusions of either pyrite or bismuth, bismuth minerals being rarely seen in this mine.

A little scheelite has been observed; it is mostly in crystal form, but some fills minute cracks in the wolfram.

The vugs of the main workings are of more than ordinary interest in that from the surface to the bottom (190 ft. down) they have been found to contain fluor.

A fine example of the intersection of two distinct pipes was observed in *Peters' Winze* below the main shaft at about the 100-ft. level. One of the pipes dips 70° to the south-east and the other, 2 ft. in diameter, dips 30° to the north-east.

The *Dane's pipe* crops near the centre of the lease and dips east-south-eastwards beneath the porphyry, but the intervening contact granite here, strange to say, is not at all greisenised. An unexpected finding was that of richly argentiferous copper-lead ore (chalcopyrite with sugary galena) at a depth of only 25 ft. For the first 70 ft. the pipe inclined 1 in 1, and the yield of wolfram was 25 or 26 tons. The shoot, 6 to 7 ft. in diameter, then ran off flatly for 40 ft., yielding 10 or 12 tons more. At this point complications were encountered. In the direction of trend of the shoot, vugs only were showing; but under foot two pipes, one 4 ft. by 2 ft. and the other 5 ft. in diameter, pitched down at 65° or 70°. One of these was followed a total distance of 110 ft. for a wolfram yield of 2 tons, the stone in the bottom being still poor. The other entered a large vug at 90 ft. down. The two shoots are said to come together again towards the bottom of the shaft, but this is doubtful. The total yield of the

pipe is variously estimated at 40 and 50 tons of wolfram, and 5 or 6 tons of molybdenite. The workings were flooded during my visit.

Devery and Trusses and Coveney's surface workings above the adit are extensive, comprising both opencuts and shallow shafts. The shoots seem to have been particularly rich on the surface.

Martin's pipe was of small size and should probably be grouped with those of the main workings towards which it pitches. At 70 ft. depth is a vug in the side of the shaft. This contained 3/20 ton molybdenite and the surrounding quartz shows wolfram freely. Just beneath this a good patch of wolfram was met but the shoot has become very small in the sink 85 ft. from the surface. Kaolinised pegmatite comes in on a ferruginous joint towards the bottom.

Truss and Norton's crooked pipe gave off branches, one of which was followed back to the surface while the other led to Martin's shaft.

Norton.

The Norton, near the hilltop to the east of the Haymaker and Gray, was among the chief producers during 1904-1906, but has shown a gradual falling off, and now it is let on tribute. Mr. Rowan, the lessee, estimates the total production at 150 tons wolfram and a few tons molybdenite. Some of the surface ground was so rich that the early fossickers won as much as half a bag wolfram per man per day, most of this having been shed from the greisen. The shallow ground should, in fact, be credited with the greater part of the yield, as the sinking was on the whole

PHOTO. 10.—NORTON IN THE DISTANCE AND EMILY IN THE FOREGROUND VIEWED FROM THE NORTH-EAST.

disappointing. Thus even the *open cut* in the northern corner of the lease was unprofitable work, as was the 60-ft. *well shaft* on the eastern corner of the Gray and one or two other shallow shafts.

On the other hand, the shoot coming down from Gray's shaft was intersected by *Grandon* at the boundary, 30 ft. below the surface, and, being followed down, gave a yield of 50 tons wolfram for 70 ft. of sinking. The shoot was somewhat flattened, being 4 ft. high and 7 ft. wide; and it consisted of bluish-white quartz in biotite greisen containing traces of molybdenite. For the first 50 ft. its inclination, which, on the whole, is east-north-eastwards, was gentle, but the shoot then pitched down at an angle of 60°, swelling at first to 20 ft. diameter and then quickly contracting. It was cut in the main vertical shaft at 70 ft. depth.

Another shoot coming down from the north-north-east, where prospected by *Rudd's and Norton's* shafts, should also be met in the main shaft, which has a depth of 170 ft., but is inaccessible in the lower part.

The *main shaft* has been for some time abandoned, but tributers are proposing to reopen it and search for the extension of Gray's shoot.

Oakvale Surprise.

This claim, the first recorded, was taken up by Mr. Freeman in 1897 on the crest of Bamford Hill. In the same year 5 tons wolfram was shipped to London, and the bismuth patch was also located. It is now part of the Haymaker.

Osborn United.

The Osborn United is one of the Rocky Creek leases, on which some of the richest alluvial has been found; two men during one wet season washed out 28 tons wolfram from one of the runs. Some sinking has been undertaken, but the holding is now deserted except for a caretaker. The yield is estimated as 110 tons wolfram and 3 tons molybdenite.

The shallow greisen of Emily Hill has been traced north-eastwards into the lease, as evidenced by the many open cuts running out in this direction.

PHOTO. 11.—OSBORN UNITED

WITH GILLIAN AND BRIDGE IN THE FOREGROUND
LOOKING DOWN ROCKY CREEK

Donoghue's 50-ft. windlass shaft in the southern part of the lease is in white quartz, containing traces of molybdenite. The country is siliceous and micaceous greisen.

Dow's pipe pitches north-eastwards, and has been worked from two shafts, of which the main one is vertical for 75 ft. and then underlies for 75 ft. It is inaccessible, but the dump is of quartz-rock and quartz with some spangles of molybdenite. The above recorded output of the mineral should be credited to this shaft, and it is understood that molybdenite is still showing in the bottom, but that it has become unprofitable to work at such a depth with a whip.

Peter's.

Peter's is an alluvial claim on Bismuth Gully, and from it during the years 1907-1912 a recovery of 10 tons of wolfram had been made. The concentrate shown me contained besides sub-angular grains of limonite-encrusted wolfram, 10 to 20 per cent. bismuth (mouse-coloured carbonate and yellow oxide, with some metallic kernels), for which, by the way, no allowance was made by the ore buyers. When water is not available, the wash, after being freed from larger boulders, is put through the dry shaker, and the concentrate so obtained is hand washed; but during the wet season the wash is treated in the banjo, elsewhere described.

At the top end of the claim the run, within which the wolfram is found in narrow trails, is about a chain wide and

PHOTO. 12.—PETER'S ALLUVIAL WORKINGS.
LOOKING UP BISMUTH GULLY.

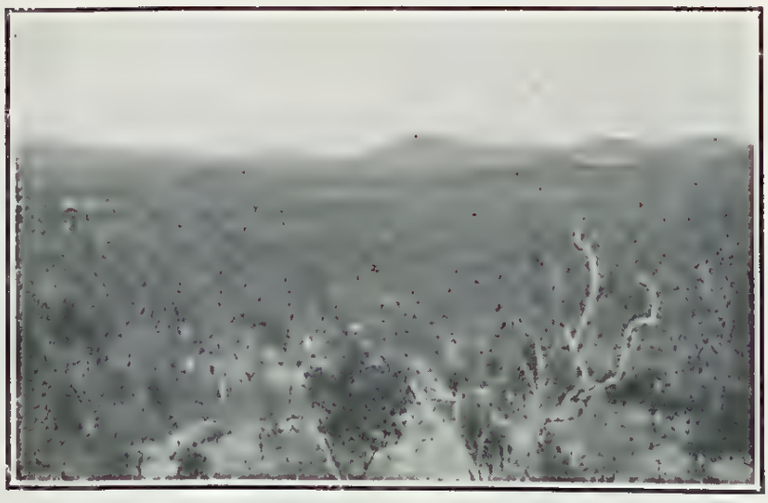


PHOTO. 13.—THE LOWER WORKINGS ON BISMUTH GULLY.
WITH BAMFORD IN THE DISTANCE.

the sinking 5 ft., but towards the lower end there is a rapid contraction. Much of the granite and porphyry wash has become cemented, and has to be broken up by means of explosives.

Rocky.

This ground is now comprised within the Trafalgar and Ballarat.

Rollinson.

The Rollinson United adjoins the Northern United on the southern end. It has been well surfaced and the underground workings are not inconsiderable. The lease during 1909 was regarded as the foremost producer of the field (during June and

July, a tributing party of five men won 12 tons of wolfram), and at the time of my visit was still being vigorously exploited. The output for the period 1905-1912 is estimated by Mr. Gouge, one of the lessees, at 83½ tons wolfram, that officially recorded for 1909 alone being 25 tons. The grade is unusually high—one 28-ton parcel assaying 73 per cent. tungstic acid, and assays of as much as 74 per cent. have been returned in the case of scheelite-bearing shipments.

The ground is notably patchy with frequent blanks, and molybdenite, though fairly abundant in the holdings on either side, is conspicuously wanting here.

A very rich run of shoad wolfram was worked down the hill from the open cut at the main shaft. From it 29 tons of wolfram was won by two men in eight months—the deepest stripping being 2 ft.

Photo. 14.—Whip Shaft, Dry Shaker, and Jig, Rollinson

The best pipe pitched north-eastwards to a depth of 40 ft. in the *main shaft*, and then fell vertically to a depth of 97 ft. The first rich ore was met at 10 ft. depth, and was stoped to the 45-ft. level for a recovery of 12 or 15 tons wolfram. A branch spur 12 ft. wide was worked up to the southwards for 20 ft. into greisen, broken up by clay dig partings dipping parallel with the contact. Again, at 65 ft. depth tributers opened out on a branch trending east-north-eastwards at first, but gradually bearing round until, at the 90-ft. level, it is but a few feet north of the shaft. The yield from the 65-ft. level was 28 tons of 73 per cent. wolfram. The mineral came in as a spot 1 in. in diameter in the middle of a mass of white quartz and gradually opened out to the full size of the drive. Another patch of 14

tons of wolfram was got between 65 and 85 ft. depths; but a large vug extended from 75 to 85 ft., and below it there has been only a trail of wolfram in the quartz. At the 90-ft. level the shaft has passed beneath the quartz into siliceous greisen containing biotite as well as muscovite. The quartz of which a face more than 10 ft. in diameter is exposed pitches flatly northwestwards.

The *main adit,* to the north-east of and 40 ft. below the brace of the main shaft crosses the contact of porphyry and granite, here underlying 1 in 1 eastwards. It was put in to cut a shoot found on the surface, where 1 ton of shoad wolfram had been got. In the greisen at the end of the adit there is showing only small bodies of white quartz with little wolfram. The adit is 65 ft. in length, and is to be continued to the main shaft.

Rose of Denmark.

The Rose of Denmark is an abandoned claim on Rocky Creek between the Rollinson and the Ferguson United. Since 1903 between 60 and 70 tons of wolfram has been won from this ground, most of it by open-cast work. In fact, the whole hillside

PHOTO. 15.—RE-TREATING DUMP.
ROSE OF DENMARK.

hereabouts has been tossed over to a minimum depth of 20 ft. Most of the output is to be credited to the early years and the shallow ground; and the mine has now been worked almost to a standstill under existing conditions.

Goldup's opencut in the south exposes quartz-rock and wolfram-bearing quartz in rough layers dipping under the porphyry beyond the creek. In one place there is 8 to 12 ft. of solid quartz-rock with scattered wolfram, overlying 3 to 6 ft.

banded siliceous greisen, which again is superimposed on decomposed greisen carrying a little molybdenite. Goldup reported in 1908 that the footwall portion of the small pipe followed was practically solid wolfram.

PHOTO. 16.—GOLDUP'S OPENCUT, SHOWING GREISEN FLOORS.

ROSE OF DENMARK.

The main underground workings are below *Nelson's* cut, in which is a vertical shaft 35 ft. deep. Two underlies leave this shaft at 15 ft. depth; the deeper underlying westwards for 15 ft. and then northwards for 120 ft., and the other underlying towards the north-east to the adit and beyond it for 90 ft. These shafts being flooded could not be inspected, but it is understood that there is a good face of quartz in the sink of the deep shaft, though the quartz lately sunk through was barren of metallic mineral. There is said to be still molybdenite showing in the quartz at the bottom of the winze below the adit, which has been driven 55 ft. through granite.

Some interesting mineral occurrences have been noticed here—that of crystallised fluorite and scheelite associated with blende and bismuthinite; but the pipes were small and very crooked.

Rose of Queensland.

The Rose of Queensland adjoins the Rose of Denmark on the western and upper side, yet it appears to be chiefly below the productive zone, for over the greater part of the claim the granite is but slightly greisenised. The shallow cuts along the western boundary are in quartz-rock, but they have yielded little ore.

One shoot has, however, been followed to a depth of 60 ft. for a recovery of 5 tons of wolfram. This in the upper part underlies at 30 degrees to the north-north-west, but near the bottom it has curved round, and is now pitching southwards at 1 in 1. It contracted from 10 ft. to 1 ft. in diameter in the lower part of the shaft, and in the sink there are to be seen only small and irregular disconnected bodies of quartz in the quartz-rock. The quartz is crystalline, and carries a little interstitial blende, galena, cupriferous pyrite, bismutite, and fluor. A specimen of galena from one of the vugs met here was assayed by the Government Analyst for Mr. Goldup, and found to contain—

$$\left.\begin{array}{l}\text{Pb} = 74{\cdot}2\% \\ \text{Bi} = \ 2{\cdot}8\%\end{array}\right\} \text{ with } \left\{\begin{array}{l}\text{Au} = 19 \text{ gr. per ton.} \\ \text{Silver} = 298 \text{ oz. per ton ;} \\ = 4 \text{ oz. per unit lead.}\end{array}\right.$$

Rover.

The Rover is now included in the southern part of the Gillian and Bridge claim.

Norris's is the only shaft; and the production was but 1 or 2 tons.

Southern Cross.

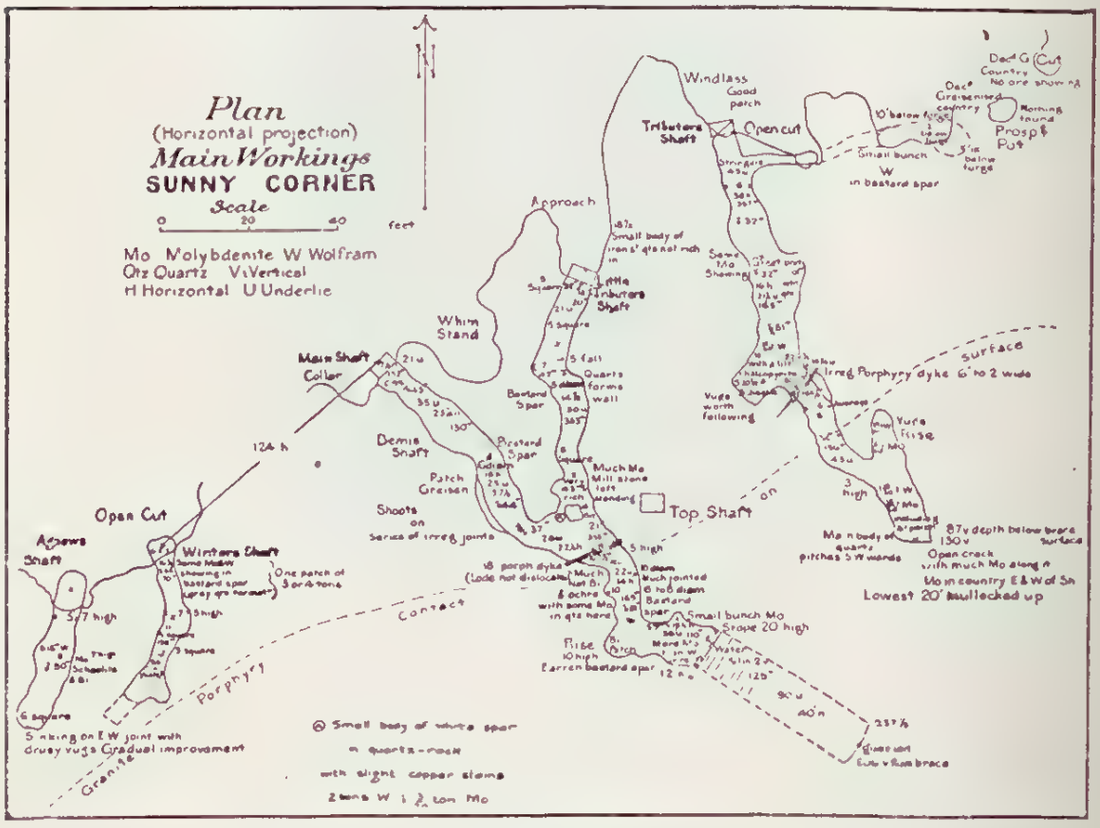
The Southern Cross is a small claim on Bamford Hill, between the Morning Star Extended and Evening Star. The rich surface ground of the Extended ran across the northern part of the claim, but there is no record of the amount of mineral won.

In the northern corner of the claim there are deep open-cuts in quartz-rock, and a shaft has been sunk on a flat angle southwards till it met the big E.-W. felsite dyke of the Extended.

Just below the surfaced ground is the *Robert and Bloomfield* shaft, which reaches a depth of 70 ft. on the underlie, and has yielded about 7 tons of wolfram. Mr. Price, who last worked in it, informs me that there is a large body of poor quartz in the bottom. There are other caved shafts near by.

Sunny Corner.

The hill on which is the Sunny Corner lease—one of the oldest and most persistent producers—is separated from the main workings on Bamford Hill by an interval of barren country and by Bamford Creek. It is capped by porphyry, but completely girt by granite; and the pipes, as on Bamford Hill, have been found in the latter rock at a little distance from the contact surface. The six main pipes worked are all on the north-western side of the cap, which brings them within the north-east and south-west productive belt of the field.



Plan 3.

The lease has turned out more molybdenite than any other holding on the field, the total quantity obtained since 1904 being 15 tons, of which two-thirds came from the main shaft. During the period 1904-1908, 60 tons wolfram was won, with assays running from 66 to 68 per cent. tungstic acid (*fide* Mr. Gouge).

The pipes or shoots are of milky white quartz, and are enclosed in the usual grey granular quartz-rock (passing outwards into greisen). They are mostly less than 10 ft. in diameter, and only very exceptionally do they swell out to 20 ft. They are most inconstant in trend as well as size; but they have a general

southerly or south-easterly dip into the hill, being controlled by a series of short irregular joints. The pipes fail along the contact to the east of the tributers' shaft, where several shallow open cuts have been opened in decomposed and greisenised granite.

The *main shoot,* sometimes called Bemi's, has been followed on the underlie (at 69° to 37°) a distance of nearly 260 ft., the sink being thus over 200 ft. below the brace. It is calculated that at about 60 ft. down the underlie the shaft passes beneath the porphyry that caps the hill. It may be mentioned that towards the last the ore was raised by means of a horse-whim, and that work has ceased at this shaft until steam gear can be installed. Below the 100-ft. level the ore carried much bismuth; and at the 150-ft. level the percentage of molybdenite was greater than that of wolfram. In all 10 tons of molybdenite came from the shaft besides wolfram, of which tributers are said to have recovered 10 tons from the old dumps alone.

The *Little Tributers* is a branch of the main shoot. It afforded some rich ore, and much milling ore has been left standing, because of the fineness of its molybdenite.

PHOTO. 17.—SUNNY CORNER, WITH END OF RAZOR EDGE IN BACKGROUND. VIEWED FROM THE NORTH.

The further deepening of these underlie shafts having become unprofitable, it is proposed that a new vertical shaft be sunk. The lessees have turned down the idea of putting in an

adit from Bamford Creek, because it could be little more than 100 ft. below the brace of the main shaft, and the sink is already more than 200 ft. beneath that datum.

The *Tributers' shoot* lies roughly parallel with the main pipe, and like it gives off several spurs or branches, one of which just beneath the surface has been traced out for a distance of 50 ft., and another of which is likely to extend to the main shaft. The shoot itself averages more than 6 ft. in diameter, and consists of milky-white quartz in a formation of greyish granular quartz-rock. Unaltered country and even greisen proper is nowhere to be seen. Several fair patches of up to 1½ ton wolfram have been found, one of them just beneath the surface. Scheelite has also to be recorded from this pipe associated with chalcopyrite in wolfram ore. The lowest wolfram bonanza yielded also 1 ton of molybdenite, and much of the same mineral is still showing in the sink along the open joint on which the shaft has been sunk. During my visit sinking had been suspended at 100 ft. on the underlie below the brace, owing to a heavy influx of water that is believed to come from the main shaft. The lower half of the Tributers' shaft is under the porphyry cap.

Winter's shoot averages 6 ft. in diameter, and dips southwards at about 55 degrees. The shaft, which is flooded below the 50-ft. level, is in vuggy grey granular quartz formation, with some molybdenite and wolfram near the surface. One patch of 3 or 4 tons of wolfram was got while the shaft was being sunk, and a ton more has been recovered since from the dumps.

Agnew's shaft was down in June, 1912, about 40 ft. in granular grey quartz-rock. A strong east-west joint marked by drusy vugs was being followed with every promise of a pipe of quartz being discovered. A little scheelite has been found, and also some carbonate and oxide of bismuth. Molybdenite is showing freely, and in the vugs has suffered oxidation to the peculiar pearly powellite, elsewhere described.

The *Top shoot* had in June, 1912, been worked to a depth of 60 ft. The wolfram being got here was in the form of dense black crystalline laths, sometimes brownish on cleavage surfaces.

Trafalgar.

The Trafalgar claim, on Rocky Creek, at the northern end of the field, has been extensively worked by open cut along a narrow run of ore. The claim has recently been called to public notice because of the successful treatment of the old molybdenite tails with the aid of oil.

A shaft known as the *Frenchman's Lig* was sunk some years ago to a depth of 100 ft. for a yield of 2 tons of molybdenite, and just lately part of the tails have been retreated (with the addition of oil) for a further yield of a ton. The shaft is said to be vertical for 40 ft., and to then underlie 1 in 2 eastwards or towards the contact. The material of the dumps is greisen and close grained biotite granite, with well disseminated molybdenite to the extent of, say, ½ per cent.; and with the present high price ruling, the occurrence should thus be looked into as a milling proposition. Small masses of galena are scattered sparingly through the greisen, in association with the molybdenite, and bismuthinite was also noticed.

PHOTO. 18.—TRAFALGAR, AS SEEN FROM THE EAST.

GRANITE KNOBS IN MIDDLE DISTANCE; PORPHYRY OF FEATHERBED RANGE ON HORIZON.

Of late months some new prospecting had been done with most encouraging results in the greisen formation up the hill from the Frenchman's shaft, in the neighbourhood of which it is rumoured that 10 tons of shoad wolfram was got by the original prospectors. One shaft has been sunk in decomposed greisen, which, where silicified along indefinite floors, carries wolfram and yellow oxide of bismuth. The wolfram concentrate obtained here assays up to 15 per cent. bismuth. Developmental work is not far enough advanced for a definite opinion to be formed

as to whether this greisen in bulk and value is suitable for battery treatment; but prospecting with that end in view is to be commended.

Violet (Grimshaw's).

The Violet is an abandoned claim adjoining and to the north of the White Elephant. Its output was small, but included a ton of molybdenite.

There are several shallow cuts and one shaft, the last sunk vertically for 30 ft., and then on an underlie for 20 ft. The shaft is said to have been almost wholly in quartz, but to have produced very little mineral. The footwall formation was a chloritic matrix, usually regarded as a good indication on the Northern United.

Violet (Lett's).

The long abandoned Violet claim adjoins the Evening Star on the south. It is understood that two pipes were sunk on till the felsite dyke of the Extended was met. The yield was small.

White Elephant.

The White Elephant is at the northern end of and partly included in the Northern United, which lease now includes the main shaft. Rumour has it that 8 tons of wolfram was won with long-handled shovel from one of the many shallow holes, and that the shoot was never sunk on. In addition, Mr. Quill has records of 9 tons of wolfram and 1 ton of molybdenite having been got.

The *main shaft*, now included within the Northern United lease, is said to be 50 ft. deep, but it is nearly full of water. The dump is chiefly white quartz and greisenised country, the latter showing molybdenite.

Young's.

Young's workings form a cross belt about 2 chains wide on the high hill to the west of the Sunny Corner and somewhat out of the productive zone. They are shallow, and no large yield is probable. The crystalline and granular quartz occurs in ill-defined nests, strung out parallel to the porphyry contact and resting on decomposed greisenised granite. Casts of molybdenite crystals and flakes are strongly in evidence in the quartz on the dumps.

TREATMENT.

The metal values of the Bamford ore do not permit of its being transported any distance to a battery, and there is only one instance of even rich pickings having been shipped for concentration. In this case 7½ tons were sent 11 miles by rail to the Koorboora battery, and yielded 16 per cent. of wolfram.

In every-day practice wolfram and bismuth ore, as it is raised from the mine, is cast on to a Bamford shaker. This machine, of which several designs are in use, is essentially a

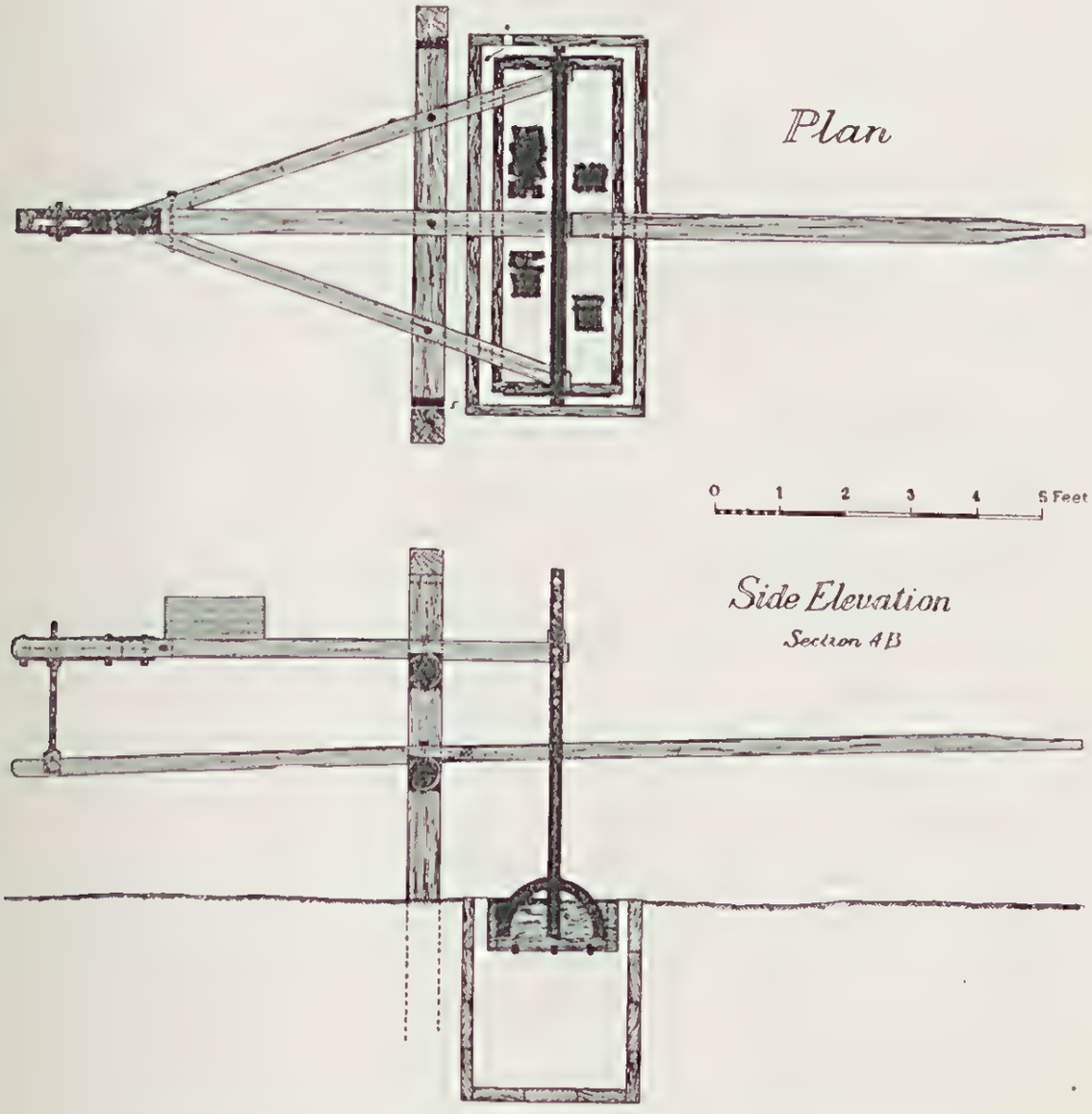


Fig. 8.—Hand Ore-Jigger used at Mount Perry. Prototype of Bamford Jig.

percussion screen, with 3 ft. x 6 ft. tray either suspended by straps or sliding on runners, the requisite motion being imparted by a hand lever working against a fixed block. The screen is

made of copper wire, and has a ½-in. mesh. The latest design, affording two products, is said to have a capacity of 12 tons of run of mine ore per hour; but even this, the best, is laborious to operate.

The fines from the shaker go direct to a wet jig, which is also worked by hand power. The jig consists of a water tank (3 ft. x 2 ft. x 1 ft.), wherein is suspended a fine screen attached to the upper of a pair of connected levers, through which it may be given a pulsating vertical motion in the water, for the purpose of effecting a separation of the wolfram gangue.

The coarse material is hand sieved, and any fragments showing metallic mineral are put aside to be spalled, the remainder going over the dump. That crushing by dolly is never resorted to may be explained by the coarseness of the wolfram and the ease with which it may be spalled out of the quartz; but the local objection to the attendant preliminary roast, with its expense of bringing fuel to most of the mines and the loss of bismuth by volatilisation, is a controlling factor.

The cleaning of alluvial wolfram and bismuth concentrates is usually effected by means of the banjo, a tom or trough intended for use when water is scarce. It is 6 ft. 6 in. long by 2 ft. at the upper end and 1 ft. at the lower. For use it is placed on a slope of 1 in 20, with the narrow end in a pool of water, the sieved material to be concentrated being piled in the upper end. Water is scooped from the pool on to the ore, and in running off washes down the lighter particles of gangue. The ore can be raised to 90 per cent. mineral by this means.

A streaming-box has to be used for the final clean-up. The latter is 5 ft. long, 7 in. wide at the top and 6 in. at the bottom end, and it is given a slope of 1 in. in the 5 ft. Water is derived from a small reservoir at the head.

Most of the molybdenite shipped from Bamford has been hand-picked, and the choice of ore has been restricted to that containing coarse nests of the mineral; but on one claim kerosene is added to the crushed ore before panning off in water, and a reasonably clean separation of the molybdenite fines is thereby secured.

12th October, 1914.

By Authority: Anthony James Cumming, Government Printer, Brisbane.

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DEPARTMENT OF MINES.

Geological Survey of Queensland.

(B. DUNSTAN, GOVERNMENT GEOLOGIST.)

PUBLICATION No. 249.

OIL SHALES

IN THE

PORT CURTIS DISTRICT.

BY

LIONEL C. BALL, B.E. (Syd.),

ASSISTANT GOVERNMENT GEOLOGIST.

BRISBANE:

AUTHORITY ANTHONY JAMES CUMMING, GOVERNMENT PRINTER.

1915.

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PREFACE.

Fuel oil and its by-products are of such immense importance to modern industry that it is undesirable to overlook any possible source of supply in a country like ours, where flowing petroleum wells are non-existent. For this reason the writer, having had occasion during the year 1913 to inspect certain oil shale areas in the Port Curtis district, described the occurrences somewhat fully; and his reports, entitled the Tertiary Oil Shales respectively of Baffle Creek and the The Narrows, appeared in the "Queensland Government Mining Journal" during last year.

After some years of idleness there has quite lately been a renewal of mining activity at Lowmead, in the Baffle Creek area, Messrs. Moffat and Taylor having started the sinking of a new shaft. In view of the almost national importance of the undertaking, I may perhaps be permitted to suggest that full data as to the strata sunk through be carefully recorded. The collection and storing of samples of each variety of oil shale met is also highly desirable, and the slight cost will be more than justified by the saving in expensive search later on.

The difficulty in securing the requisite capital referred to below is being overcome, and arrangements have been made for the installation during the next six months of an experimental unit upon a working scale of a shale distillation plant.

The publication of the reports in bulletin form but otherwise without substantial alteration should therefore not be inopportune at the present juncture.

27th March, 1915.

Tertiary Oil Shales of Baffle Creek.

By Lionel C. Ball, Assistant Government Geologist.

INTRODUCTION.

In the upper part of the Baffle Creek valley, about midway between Gladstone and Bundaberg, is an area of fine-grained sediments, which, by reason of the fact that certain of the beds owing to their carbonaceous nature yield an oil when subjected to destructive distillation, are likely to be of some economic value in the not distant future.[1] The area extends back 2½ miles from the creek towards the North Coast Railway line from near Lowmead almost to Colosseum (railway stations distant from Brisbane respectively 265 and 279 miles).

Topography.

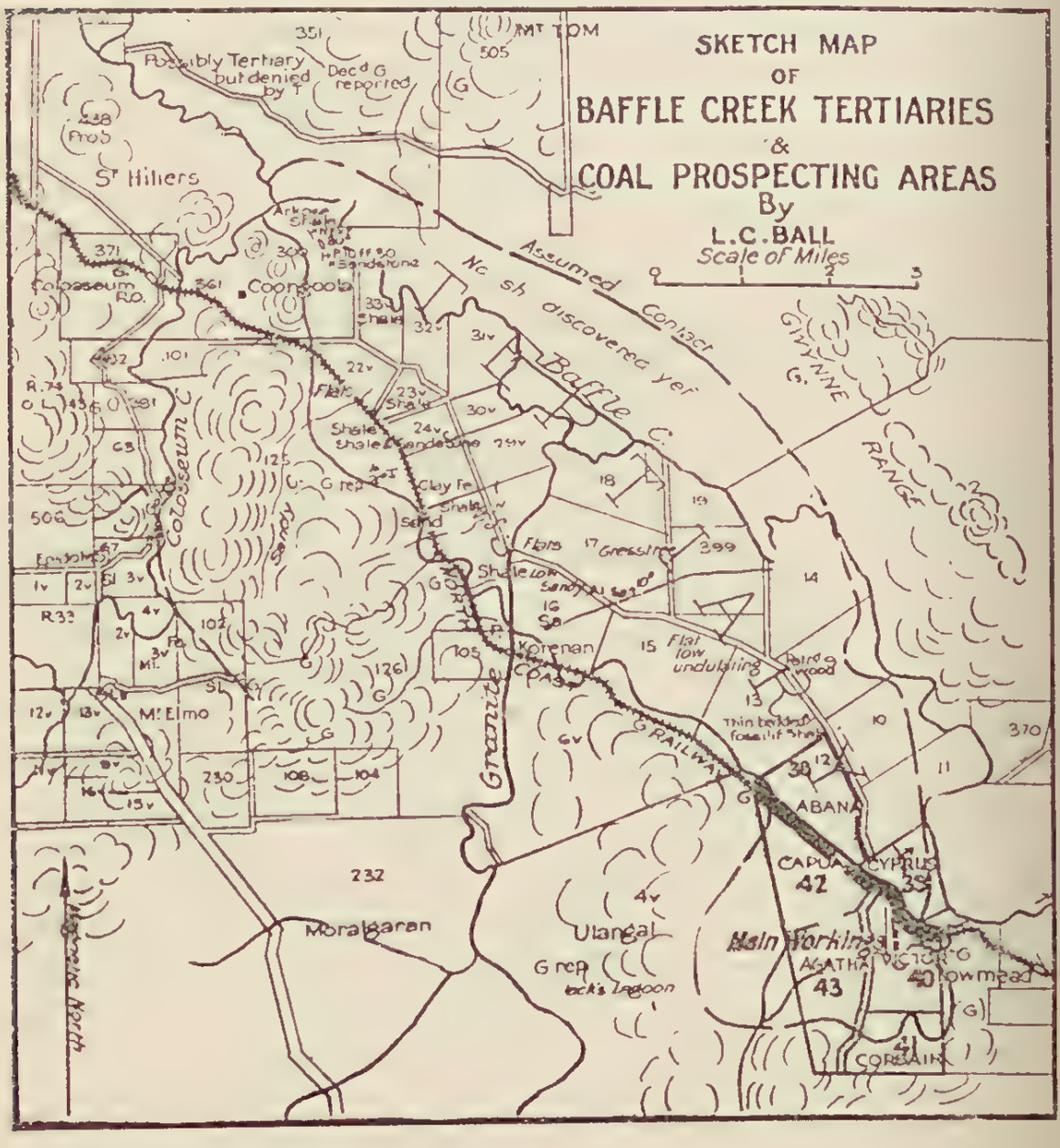
The relief of the country is subdued, the gently undulating ridges seldom rising more than 100 ft. above the creeks. Baffle Creek itself is a strongly flowing stream, as are its tributaries Harpur, Granite and Colosseum Creeks, all of which traverse the Tertiary terrain and exhibit the striking physiographic peculiarity known as boat-hook bends, which point unmistakably to stream piracy. Proofs are not wanting of oscillations in the level of the earth's crust in the Port Curtis District during comparatively recent times, and a slight upheaval of the country immediately south of Rodd's Bay may be assumed as the cause of the damming back of the head waters of a drainage system formerly emptying into Rodd's Bay, with the formation of a lake wherein were deposited the sediments under notice. The ultimate draining of the lake will have been due to the cutting

[1] Mr. J. Taylor is credited with being the discoverer of the oil shales in this district, and it was he who brought them under the notice of Mr. John Moffat, of Irvinebank, with a view to their commercial exploitation. I have to express my indebtedness to Mr. Taylor for much information about the field, and for guidance over it in July last, and to Mr. Moffat for permission to make public the result of the prospecting carried out by him.

through of the barrier again on the north, and, though further warping of the crust reimposed the barrier, the formation of a lake was prevented by the contemporaneous action of Baffle Creek in gapping the southern edge of the basin and so reversing the direction of drainage.

GEOLOGY.

The strata lie at the bottom of an old granite valley; and in close proximity to the surrounding granite ridges the sediments have the nature of arkose. but elsewhere very fine-grained shales, clays, and argillaceous sandstones predominate.



It is noteworthy that the shales closely resemble those of the Oxley District, near Brisbane, not only in lithological characters but in their fossil contents. and consequently they are here provi-

sionally classified as of Tertiary age. In several places the outcropping beds have been found by Mr. J. Taylor to be highly fossiliferous, the leaf impressions being so numerous that at the time of sedimentation the vegetable substance must have been far in excess of the mineral matter. The forms are not unlike those of many present day plants, but, bearing in mind the danger of attempting to identify plant genera on the evidence of the leaves alone, I hesitate to do more than state that they resemble *Diemenia* or *Litsea, Cinnamomum, Cupanites, Ficus, Apocynophyllum, Bombax, Acer, Populus,* &c., most of which occur in the Tertiaries of Southern Queensland and New South Wales. A small fragment of what appears to be a Taeniopterid was obtained and this opens up a still wider field for speculation. The *Unios,* which are associated with the plant remains, are not likely to be of any greater value as criteria of age.

The strata have been much disturbed since their deposition, and in many places they dip as much as 30°, though never for long distances, the structural forms prevailing being short anticlines and synclines. The total thickness of the beds is unknown, and it is doubtful if an estimate could be arrived at without boring or shaft sinking. The crops in the southern part of the field have a north and south trend, but in the central part their strike is east and west, and at the northern end they have swung round again towards the north-west. The more prominent outcrops within the coal prospecting areas are described under their respective captions, but there are a few others worthy of separate mention.

Towards the northern end of the Tertiary terrain on Freehold No. 300, Miriam Vale, 2 miles east-north-east of Colosseum, there is a bluff, about 30 ft. high, of sandstone, arkose, cement and conglomerate; and beyond this again to the north slightly indurated sandstones and shales are well exposed. Their dip is here 30° to north-east-by-east.

The clayey strata are exposed in the bank of Carlo's Creek (a small tributary of Granite Creek) just below the railway line and about a mile north-west of Korenan siding. Mr. J. Taylor informs me that this material was formerly quarried by the blacks for use as war-paint or pipeclay and by them called "korenan."

Again, on portion 17, Warro, there are pronounced crops of shale and fine-grained sandstone rich in fossil leaves. The beds dip at 10° to the north-north-west.

The Oil Shales.

Some of the shales are rich in carbonaceous matter, and, as on destructive distillation they yield oil,[2] they are referred to as oil-shales.

In the thicker beds these are of various tints of brown and grey, of comparatively low specific gravity, have a sub-conchoidal fracture, are imperfectly sectile and the greasy surface produced by the knife-blade is darker than that of the natural fracture. On exposure to the weather they bleach on the surface, but whether internal chemical change results has not been ascertained. They are plainly very high in ash, but they are believed to yield oil at the rate of about 10 gall. per ton of shale. One sample that Mr. J. Moffat sent to Scotland yielded oil at the rate of 12 gal. per ton, together with 18·29 lb. sulphate of ammonia, and one of my own samples of like grade in oil gave nitrogen equivalent to 37·6 lb. ammonium sulphate, results much below the average obtained in practice from the Scottish oil shales. It is believed that Mr. Moffat's sample came from the surface, and better results may be expected from the shale below.

The richer shales (from Nos. 1 and 2 shafts) have a tough leathery nature but split up into thin lamina after exposure to the weather, and these exhibit great numbers of minute flattened oval bodies not unlike those found in kerosene shale,[3] in Tasmanite,[4] and in torbanite,[5] which are believed to be of vegetable origin. I am inclined nevertheless to regard those of Baffle Creek and The Narrows[6] as the remains of ostracods (minute marine or freshwater crustaceans), so that the kerogen in these cases may be partly if not wholly of animal origin. The shale is readily combustible, burning with a long smoky flame, and emitting a strong odour of kerosene. Mr. Moffat reports that it yields up to 82 gal. of oil per ton of shale (*see* No. 2

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[2] The Government Analyst (Mr. J. Brownlie Henderson) reports in connection with his determinations of the yield of oil from my samples: "The method employed was to distil 50 grammes of the air-dried shale from a 150cc. distillation flask of Jena glass. The flask was surrounded by wire gauze and asbestos, and the temperature raised gradually until no more distillate came over. The highest temperature of the distillate, taken as usual opposite the side neck in the flask, was just over 360° C. As is well known, the quantity and quality of the oil produced by shales on heating them depend very greatly on the method of distillation employed, it being possible to materially vary the quality and amount of the product by varying the rate and intensity of heating."

[3] "The Kerosene Shale Deposits of New South Wales." By J. E. Carne, 1903.

[4] "The Tasmanite Shale Fields of the Mersey District." By W. H. Twelvetrees, 1912.

[5] "The Oil Shales of the Lothians." By Cadell, Wilson, Caldwell, and Stewart, 1906. "The Oil Shales of the Lothians." By Carruthers (Cadell and Wilson), Caldwell and Steuart, 1912.

[6] See below.

shaft, Victor) and 270 lb. of paraffin wax. This, with paraffin selling at 2¼d. per lb., has a value of £2 10s. 7½d. The latter result was obtained from the treatment of but 5 gr. of the material, and its value is thereby somewhat discounted; but still Messrs. Johnstone and Sons returned 76½ lb. paraffin (*see* shafts Nos. 1 and 2), which is more than five times the average content of the Scottish shales—*i.e.*, 14¾ lb. per ton. The highest ammonium sulphate yield yet recorded (*see* Nos. 1 and 2 shafts) is 21 lb. per ton of shale, and this is much below the average yield of the Scottish oil-shales.

The thickness of the richer shale beds is shrouded in doubt; but, if, as Mr. Taylor believes, the greater part of the "shale" in Nos. 1 and 2 shafts is the Tasmanite-like material, the total thickness may be 9 or 10 ft., and this under ordinary circumstances it should be eminently profitable to exploit.

Petroleum.

The fact of oil-shale having been found has given rise in the minds of many people to the idea that the discovery of petroleum must be a natural corollary; but such is not the case. The oil shales in themselves are no indication whatever of petroleum, for they contain no oil as such, though their included carbonaceous matter when subjected to heat breaks up into various gaseous and oily hydrocarbons, just as do many coals. The possibility is not, however, denied that the deeper seated shales may have been subjected naturally to destructive distillation with the production of petroleum, and that such may be stored in the more porous beds; but in favour of this I found no positive evidence in the field. As to whether petroleum, derived from plutonic sources, lies trapped beneath the shales also remains to be proved by boring.

Mr. John Moffat, writing under date 28th July of this year—*i.e.*, subsequently to my return to headquarters—stated that an expert employed by him "after carefully going over a large extent of the country and examining one of the creeks . . . saw evidences of oil gas rising out of the soil and forming an oil scum on the water." It is regrettable that the locality of this seepage has not been fixed, as the confirmation of the occurrence of natural oil on the surface and within the sedimentary terrain would abundantly warrant the initiation of an extensive campaign of boring.

In this connection it is interesting to note that petroleum has been found in small quantities over a wide area in the oil shale fields of Scotland, in some cases associated with a strong brine.

Mr. R. D. Steuart says:[7] "Regarding the origin of petroleum which is represented in our field, it may be noted that all ordinary fermentations and decompositions on the surface of the earth are the result of microbe action; and they may also be involved in the changes that take place in the strata below the surface. Kerogen—'the carbonaceous matter in the shale that gives rise to crude oil in distillation'—and petroleum may possibly originate from the same kinds of organic matter, but acted on by different microbes soon after deposition or subsequently. . . . Petroleum everywhere seems associated with brine or salt from an ancient sea. The antiseptic action of the brine would kill off many kinds of microbes and give the advantage to others that would multiply and might thereby produce petroleum. At Broxburn . . . . it is probable that the petroleum was not the product of ordinary distillation of the shale. . . . It is more likely that the brackish lagoon became charged with sea-water and was separated from the ocean. Concentration then took place, and the petroleum here, as elsewhere, was formed at a not very high temperature." Cases are cited of the recent production of petroleum in peat bogs owing to the infiltration of salt water.

No marine strata have yet been recognised in the Lowmead Tertiaries, nor are there any known occurrences of brine, so that the conditions postulated above for the production of petroleum cannot be said to have obtained there.

HOLDINGS.

All prospecting hitherto done is to be credited to the initiative of Mr. John Moffat, of the Irvinebank Company, and Mr. J. Taylor, of Mount Elmo. An attempt was made in 1910 to raise capital to work the shales, and, though it was unsuccessful, it is believed that negotiations have been renewed.

In all, six coal prospecting areas have been applied for during the last four years in Mr. Moffat's name. They are called Abana, Agatha, Capua, Corsair, Cyprus, and Victor. Sinking has been restricted to the last-mentioned.

Abana (C.P.A. 38).

The Abana (area 617 acres) takes in the whole of portion 12, Warro, which is on Reedy Springs Creek to the north-east of the railway line.

Sandstone and shales, the latter with petrified wood, crop on the road to the east of the portion, and shale with petrified wood

[7] Op. cit., p. 165.

has been found in sinking potholes along the northern boundary. It is therefore likely that oil shales will be found on sinking hereon.

Agatha (C.P.A. 43).

The Agatha (area about 640 acres) is on the eastern side of 4v, Warro. Shales and sandstones crop along the eastern side but granite comes in towards the southern end, and that part of the area will be non-productive. No work has been done on the holding, but Nos. 1 and 2 shafts of the Victor are only a few chains to the east, and the shales found therein must continue into the Agatha.

Capua (C.P.A. 42).

The Capua (area about 640 acres) is on the southern side of the railway line between the Abana and Agatha. No work has been done hereon, but the sediments are believed to extend over the greater part, the granite not appearing till towards the western boundary.

Corsair (C.P.A. 41).

The Corsair (area 468 acres 2 roods) is the southern part of portion 30, Warro. The sediments occur along the northern boundary, but the greater part of the area is granite country and valueless from an oil shale producing standpoint.

Cyprus (C.P.A. 39).

The Cyprus (area about 640 acres) lies between the railway line and Baffle Creek, and is to the south-east of the Abana. Here again no work has been done, but there are several outcrops of richly fossiliferous shale with abundant petrified wood in the western part. These are plainly the continuation of the strata tested by the shafts on the Victor to the south. The country in the eastern part of the area is granitic and valueless.

Victor (C.P.A. 40).

The Victor (area about 640 acres) comprises more than half of portion 30, Warro, which lies a little over a mile west of the Lowmead railway station and on the southern side of the railway line. The area is traversed by Harpur Creek and its tributaries, Marked Tree and Hobble Creeks.

Shales and sandstones outcrop in the bed and banks of all three creeks, and they have also been well exposed by the railway cutting at the northern end of the area. It can be taken that they extend over the whole holding except a small area in the north-eastern corner where granite crops.

The strata in the *railway cutting* are thin bedded and dip at low angles (up to 45°), forming shallow synclines and low anticlines. The shales, which are fossiliferous, have been bleached and rendered absorbent by exposure. They are well laminated, and are interbedded with layers of coarse sandstone up to 4 ft. thick, and one thin band of clay ironstone has also been observed. In the following section, which is by no means well exposed, a double anticline is indicated:—

Shale, dipping 30 east-south-east. Syncline?
5 ft. sandstone
10 ft. shale
4 ft. sandstone
30 ft. shale much slacked to mud. Dip flatter and towards north-west. Anticline?
2 ft. sandstone
6 ft. shale
4 ft. sandstone
Approx. 50 ft. white shale slacked to mud and containing a few bunches of iron ore. Syncline?
1 ft. clay iron
10 ft. reddish sandstone of uncertain dip
Approx. 50 ft. shale slacked to mud. Dip probably east-south-east. Anticline?

From the railway the crops are easily traceable southwards towards the workings, where fossil Unios become more abundant.

Just beyond the workings in the bed of *Harpur Creek*, near the centre of the area, the shales show white or neutral tinted on the surface, but a few inches below they are dark brown, slightly sectile with a greasy streak, and they have a subconchoidal fracture. Mr. Taylor informed me that specimens from this locality have been reported to yield at the rate of 46 gal. of crude oil per ton; but a small sample (595) of the shale obtained by me gives (Government Analyst):—

Analysis—
Total nitrogen = 0·36 %
= 38 lb. ammonium sulphate per ton
Yield of oil, equivalent to 12 gall. per ton
Nature of oil—Medium liquid.

In 1904 Mr. Moffat had shale from the bed of either Harpur or Marked Tree Creek analysed with the attached result:—

Proximate analysis*—	
Volatile hydrocarbons	29·4 %
Fixed carbon	8·8 %
Ash	61·8 %
	100·0 %

* Comparable with that of Scottish oil shales.—L.C.B.

Shale from one of these creeks (the exact location is doubtful) was examined by Messrs. Ronald Johnstone and Sons,

of Glasgow (*see* report referred to elsewhere), who give:—

Proximate Analysis—

Volatile hydrocarbons, &c.	22·80 %
Fixed carbon	1·05 %
Sulphur	1·00 %
Ash	72·25 %
Moisture	2·90 %
	100·00 %

Specific gravity of shale, 1·37
Yield of crude oil (sp. gr. ·905) per ton of shale, 12 gall.
Yield of ammonia per ton of shale, 4·48 lb. (equivalent to 0·20 %)
Yield of sulphate of ammonia per ton of shale, 18·29 lb.

In the bank of *Marked Tree Gully* just below Nos. 1 and 2 shafts there is exposed:—

3 ft. white shale
1 ft. 6 in. red and white mottled shale
1 ft. 6 in. sandy shale
4 ft. white shale with red stains
1 ft. 6 in. brown shale (probably a decomposed oil-shale)
8 ft. white aluminous shale
3 ft. soft brown clay (sample 556)—probably yield oi
6 ft. massive white shale with fossil leaves.

The Government Analyst returns for a sample (556) of the soft brown clay:—

Proximate analysis—

Moisture	4·17 %
Volatile matter	10·0 %
Fixed carbon	0·5 %
Ash	85·4 %

Analysis—
Total nitrogen = 0·04 %
= 4·2 lb. ammonium sulphate per ton
Yield of oil—trace.

No. 1 shaft is on the northern side of Marked Tree Creek, 2 miles west-by-south of Lowmead railway station.

The shaft has now caved in, but on the dumps of greenish clay (disintegrated shale) there are a few small pieces of dark thinly laminated material not unlike Tasmanite, which Mr. Taylor tells me is the substance of the "shales" of both No. 1 and No. 2 shafts. From Mr. Moffat's records I learn that the shaft passed through 69 ft. of soft clays, with three bands of oil shale:—

Top band, 16 in. to 2 ft. thick, at 13 ft. depth.
Middle band, 4 ft. 6 in. thick, at 31 ft. depth.
Bottom band, 4 ft. thick, at 64 ft. depth.

The following analyses (attached to the same records) are believed to refer to samples from the bottom band:—

—	No. 1. Dark-coloured pieces.	No. 2. Light-coloured pieces.	No Dark-coloure pieces.
Volatile hydrocarbons	48·5	35·4	47·1
Fixed carbon	7·0	5·3	7·8
Ash	44·5	59·3	45·1

No. 2 shaft is a few chains south-east of No. 1. It was sunk to a depth of 95 ft., but has now caved in. Most of the dump consists of shale slacked to a plastic clay, but there is a small quantity of the Tasmanite-like material. This after several years' exposure has a greenish tinge, but when first raised is said to have been nearly white; on the laminæ there may be distinguished innumerable flattened spore-like bodies, about 1-50th in. long and 1-100th in. wide, having a white nacreous coat.

A weathered specimen that had lain exposed on the tip for some years and yet readily ignited upon the application of a flame was secured by me and submitted to the Government Analyst:—

Proximate analysis—

Moisture	4·4 %	Total nitrogen = 0·28 %	
Volatile matter ...	29·9 %	= 29·6 lb.	ammonium sulphate per ton
Fixed carbon	3·1 %		
Ash	62 6 %	Sulphur ... = 1·0 %	

Yield of oil equivalent to 38 gall. per ton

Nature of oil—viscid liquid.

Mr. Moffat's records show that at 28 ft. depth there is a bed of shale 1 to 5 ft. thick, and that at 87 ft. depth there is another 5 to 6 ft. thick. A sample from the latter bed was examined for Mr. Moffat in 1909, with the subjoined results, the analyst being Mr. W. Gentles:—

Proximate analysis—*		
Water lost at 100° C	2·80 %	
Volatile hydrocarbons	43·72 %	
Fixed carbon (by difference) ...	9·82 %	
Ash	43·66 %	
	100·00	
On distilling the shale gave—		
Crude oil (sp. gr. ·818)	30·0 %	equivalent to 82 gall. per ton of shale
Water and ammonia	14·5 %	
Fixed carbon and ash	55·0 %	
	99 5 %	
Analysis of ash—		
Silica...	41·60 %	
Alumina	40·70 %	
Ferric oxide	3·20 %	
Lime	12 50 %	
	98·00 %	

* Comparable with Scotch oil shale though lower in ash and much higher in volatile hydrocarbons.—L.C.B.

Mr. Moffat has lately had a further examination made of the Tasmanite-like material from the bottom shale bed, and informs me that "Mr. Gentles tested 5 grains of the sample, and to-day he handed me the resulting paraffin wax in a watch glass, which weighs equal to 12·4 per cent. of the weight of the shale tested (equal to about 270 lb. to the ton)."

Messrs. Ronald Johnstone and Son, of Glasgow, reported in May, 1910, as below:—

"A specimen of a bulk lot received from the property as characteristic of the shale seams† from "A" and "B" [Nos. 1 and 2, L.C.B.] shafts was sufficient for us to run out an approximate analysis, and the following were the results obtained ":—

Proximate analysis—	
Volatile hydrocarbons, &c. ...	36·68 %
Fixed carbon	5·05 %
Sulphur	3·25 %
Ash	54 50 %
Moisture	0·52 %
	100·00
Specific gravity of shale	1·33
Crude oil (sp. gr. ·895) yield per ton of shale	45 gall.
Ammonia yield ·24 %	5·37 lb. per ton
Equivalent sulphate of ammonia ...	21·99 lb per ton

"The crude oil is of good quality and on a fractional distillation gave the following approximate results :—

Sp. gr. of crude oil ...	·895
,, once run oil ...	·891—proportion 95 %
,, oil after chemical treatment ...	·870—proportion 90 %
Setting point of crude oil	30·0
Coke by weight	2·40 %
Sulphur in crude oil ...	·57 %

Products—	
Spirit and burning oil (sp. gr. ·800) ...	24·00% by volume
Lubricating & intermediate oil (sp. gr. ·800)	30·00 %
Paraffin scale	20 00 % ‡
Loss by refining	26·00 %
	100·00

"The various oils, as far as could be judged from the smallness of the quantities, appear to be of good quality. There is a rather large percentage of sulphur in the shale, but as to whether this would give trouble in refining the crude oil or not, it would be impossible to definitely state until a larger test was run. We may, however, from our experience state we do not anticipate any difficulty on this score. The yield of paraffin wax, the most valuable of all the products obtained from the distillation of shale, is abnormally high, and in consequence very much enhances the value of the proposition.

† This must have included some of the Tasmanite-like material and may have consisted wholly of it.—L.C.B.

‡ Equal to 76·50 lb. per ton of shale.—L.C.B.

It may here be mentioned that the original Torbanehill mineral yielded only 1 to 1½ per cent. crude paraffin, as against 3·4 per cent. (76·50 lb. per ton) in the above sample.

No. 3 shaft is within a chain of the northern bank of Harpur Creek, 1¾ miles west of Lowmead and ½ mile north-by-east of No. 1 shaft. It could not be entered because of water, but Mr.

Moffat's records give its depth as 63 ft., with the attached section:—

4 ft. 6 in.	—loose friable sandstone.
12 ft.	—gritty clay, with thin layers ferruginous sandstone.
6 ft.	—shale, with layers ½ to 1 in. thick, carrying some iron.
1 ft. 6 in.	—light-brown shale.
9 in.	—soft sandstone.
3 ft. 6 in.	—hard sandstone.
3 ft.	—good looking shale.
1 ft.	—darker shale.
1 ft.	—black shale (of low specific gravity).
3 ft.	—good looking shale.
3 in.	—band hard iron stone.
3 ft.	—good looking shale.
5 ft.	—shale.
9 in.	—hard sandstone.
9 ft.	—shale.
3 in.	—coal (thickness doubtful).
8 ft.	—lighter coloured shale.
62 ft. 6 in.	("including 26 ft. shale.")

The greater part of the dump comprises conchoidally breaking low-grade oil shale and grit, and there is paddocked separately about a ton of impure lignitic coal, a sample (558) of the cleanest of which has (Government Analyst):—

Proximate analysis—

Moisture	12·4 %
Volatile matter	36·8 %
Fixed carbon	32·2 %
Ash	18·6 %

Analysis—

Total nitrogen = 0·90 %
= 95 lb. ammonium sulphate per ton

Yield of oil equivalent to 27 gall. per ton.
Nature of oil—viscid liquid.

The shales crop in the bank of Harpur Creek within 40 ft. of the shaft. They are there bleached white and neutral tinted, but become dark brown within a few inches of the surface, being then slightly sectile, with a greasy brown streak. A sample assayed for Mr. Moffat in 1904 was probably derived from this place:—

Proximate analysis*—

Volatile hydrocarbons	29·4 %
Fixed carbon	8·8 %
Ash	61·8 %
	100·0 %

* Comparable with Scottish oil shales.—L.C.B.

The bedrock of the creek here is shale, but great quantities of sand have been washed down from the granite country at the head of the creek. During dry spells water can be got only by sinking into this sand, and it is said then to have a most

objectionable taste. This is probably to be ascribed in part at least to the presence of magnesia, which is usually a prominent constituent of waters derived from granite country. The taste has been ascribed by some to oil in the water, but oil if present in large enough quantity to afford a distinct taste to the water would also form an unmistakable film on its surface; and such has not been noted by me.

No. 4 shaft[3] is one-eighth of a mile north of No. 3. Mr. Moffat's records give its depth as 85 ft., and the following section is from the sinker's log:—

	5 in.—dark clay.
	9 in.—kaolin.
	9 in.—red kaolin.
10 ft.	—soft red formation.
2 ft.	—hard ironstone and gritty sandstone.
15 ft.	—hard kaolin with some oxide of iron. Leaf impressions.
3 ft.	—chocolate stuff.
1 ft. 3 in.	—hard rock.
4 ft. 6 in.	—tough shale.
	6 in.—grey fossiliferous shale.
6 ft.	—hard tough shale with a few fossils.
6 ft. 6 in.	—very poor quality shale.
3 ft.	—darker shale.
12 ft.	—shale.
	6 in.—hard hand.
18 ft. 6 in.	—better quality shale burning freely in fire. (Samples at 68 ft. and 78 ft.) (Heavy water struck at 71 ft. depth). Lower grade towards bottom, and increased flow of water.
84 ft. 8 in.	("including 48 ft. shale.")

The larger dump is chiefly fine-grained conchoidally breaking, neutral-tinted, slightly sectile shale of low specific gravity and greasy streak (sample 557). Weathered faces are bleached and exhibit a minute pitting perhaps from the removal of the substance of minute organisms. A few fossil leaves were found, and there are also charcoal fragments, besides which some of the more gritty bands are highly carbonaceous (sample 559):—

	557.	559.
Proximate analysis—		
Moisture	3·9%	3·7%
Volatile matter	14·3%	12·6%
Fixed carbon	4·3%	5·4%
Ash	77·5%	78·3%
Analysis—		
Total nitrogen	0·30%	0·22%
Equivalent ammonium sulphate, lb. per ton	31·7	23·2
Yield of oil in gallons per ton	10	7
Nature of oil	Medium liquid	Medium liquid

[3] The condition of the timbers and the flooded state of the shaft did not permit of my descent.

CONCLUSION.

From the above it is apparent that there are in this district several beds of shale from 5 to 50 ft. in thickness of various and uncertain values as oil producers; for, though analyses are given above showing yields of as much as 82 gal. of crude oil per ton of shale and as much as 270 lb. of paraffin wax, the shaft sinkers did not undertake systematic sampling of the whole of each bed. It is a pity that proper samples were not kept of all strata met in sinking, as to obtain such now new shafts or bores will have to be sunk; but if the shafts were cleaned out samples of the oil shales most likely could be obtained. Meanwhile samples were taken by me of the shale on the dumps at the shafts, of the coal at No. 3 shaft, and of the outcropping shale on Marked Tree and Harpur Creeks; and from the analyses of these it is gathered that the immediate future of the field turns on the thickness of the Tasmanite-like shale met in Nos. 1 and 2 shafts. If the total thickness—10 ft. in No. 1 and 9 ft. in No. 2—should be of the quality of my sample from No. 2 shaft, of which an analysis is given above, the grade will be all that could reasonably be desired—that is, by anyone contemplating the erection of shale treatment works. The only disturbing factor will then be the soft nature of the interbedded clay-rocks, which it is feared will render exploitation both difficult and costly.

Brisbane, 23rd December, 1913.

Tertiary Oil Shales of The Narrows.

By Lionel C. Ball, Assistant Government Geologist.

INTRODUCTION.

A narrow belt of soft sediments of probably Tertiary age extends along The Narrows (that strait which connects Keppel Bay and Port Curtis and separates Curtis Island from the mainland), and these presumably occupy the site of an old basin, The Narrows themselves being a later drowned valley of typical form. On the mainland the deposits extend on the north-west from a point on the coast between 3 and 4 miles west of the mouth of Munduran Creek to Targinie Creek, nearly 16 miles distant to the south-east; and they extend inland from 1 to 2 miles. The chief development on Curtis Island is on Reserve 28, between Badger and Monte Cristo Creeks. To the southwards the old valley trended away from what is now the island and also in fact from the main channel of The Narrows.

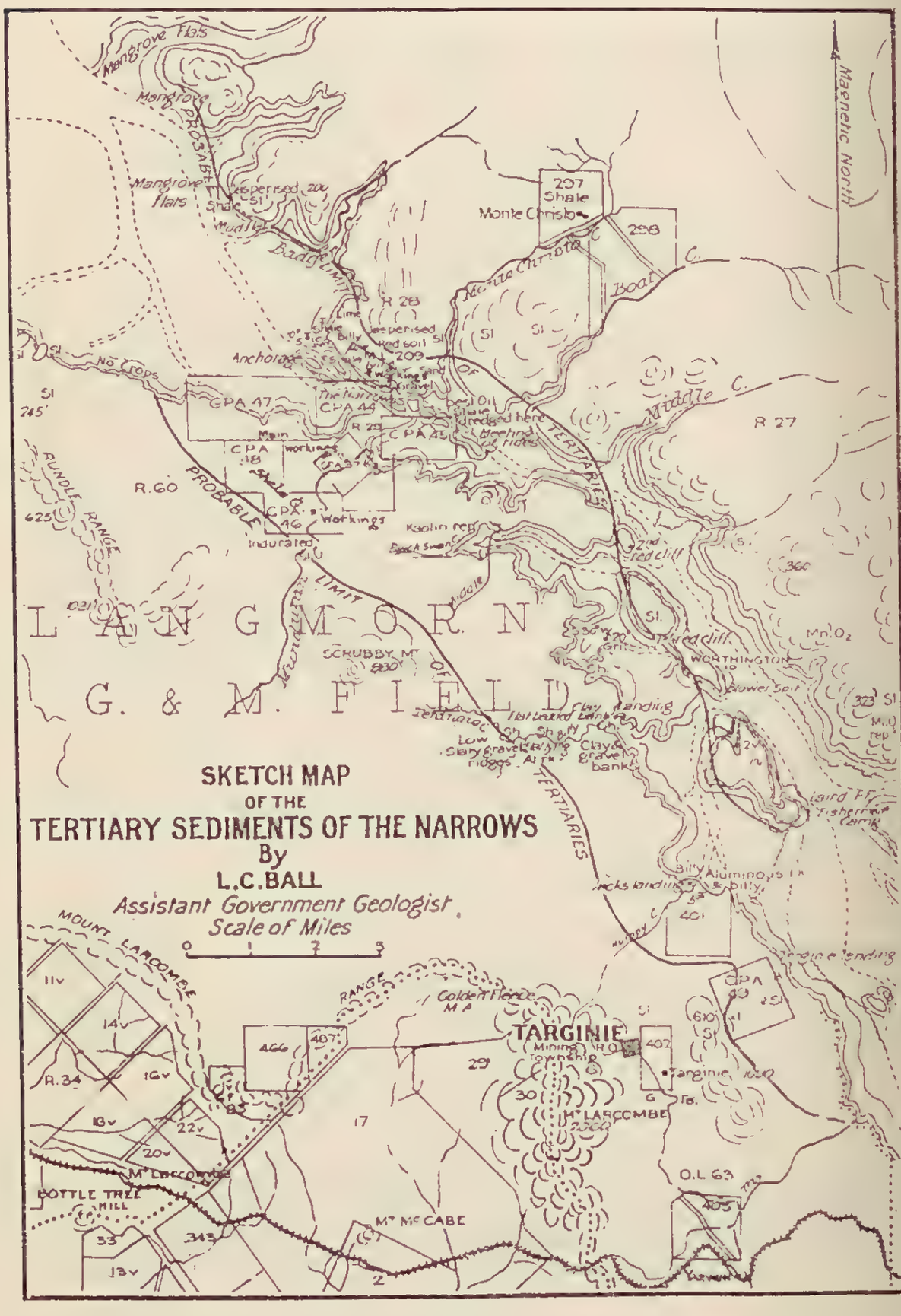
The surface of the Tertiary terrain is nowhere more than 100 ft., and in most parts is not more than 50 ft., above sea level, the ground rising very gradually from the shoreline. Few creeks traverse it, Munduran being the only one of any size, and, as there has been but little incision, outcrops are seldom seen; consequently the exact determination of the limits of the Tertiary area would be a matter of some difficulty and would require more time than could be spared; but on the attached plan an attempt has been made at an approximation.

History.

Towards the end of the year 1911 Messrs. Spresser and St. Ledger applied for and were granted assistance to search for an alleged combustible clay (supposed to be petroleum-saturated), occurring in the vicinity of Munduran Creek; and though, after three months in the field, they admitted failure in this,[1] they

[1] Two samples, one of a yellow and the other of a red muddy liquid, were brought back by the prospectors as from supposed seepages, but the Government Analyst found no oil in either.

described the country as most likely-looking for petroleum and they also brought in a block of pure white clay from Curtis Island for determination as to its nature and value. Subsequently, in May last, they marked out three oil prospecting areas (under the



new Act of 1912) and one mineral (fireclay) lease, all in the vicinity of Elwing's old holding (C.P.A. 37, including forfeited M.L. 196) on Munduran Creek. Their activity in the field had,

however, attracted the attention of others, and Messrs. Morgan and party, of Brisbane, had applied some days earlier than the prospectors for a license to occupy as a prospecting area for oil Crown land in the same locality, while shortly after Mr. Chisholm, of Targinie, pegged out another oil prospecting area, also near the mouth of Munduran Creek. Before the end of the same month Messrs. Pujalas and Crosisco, of Targinie, put in an application for a prospecting area for coal (which under the Act includes fireclay), the location of the area being between the town mentioned and The Narrows, some 11 miles south-east of the mouth of Munduran Creek. C.P.A. 37 was secured with a view to prospecting for oil shale or coal and fireclay, but the others have been taken up in anticipation of petroleum being located, the oil shale and fireclay thereon being regarded as of no particular present value.

My visit to the locality was made in July last at the request of Mr. Spresser, for the purpose of deciding whether the country was structurally favourable for the natural underground storage of petroleum, without necessarily making a pronouncement as to its presence.[2]

GEOLOGY.

The bulk of the Tertiary formation is built up of shales—white, mauve, and green—which sometimes pass into argillaceous sandstone. In the southern part of the area—*i.e.*, to the east of Targinie—beds of impure brownish granular siliceous sinter are interbedded with shales, which in the same locality are characterised by the inclusion of masses of pure white absorbent siliceous material, resembling diatomaceous earth, but with the texture of porcelain, and often grading into an impure vitreous flint or chalcedony. Other siliceous beds in the south contain abundant indistinct impressions of plant remains, as do the more earthy shale bands to the north. There are also more definite representatives of the animal kingdom, the best being a gasteropod found in high grade oil-shale in Munduran Creek; but similar casts of a small gasteropod are distributed plentifully through the masses of white siliceous rock mined as kaolin near Targinie landing. These may be of some service in arriving at an estimate of the geological age of the deposits. Other organisms to be referred with less confidence to the animal kingdom are the minute reniform bodies—between $\frac{1}{200}$ and $\frac{1}{100}$ in. in length—showing in vast numbers on the bedding planes of some of the shales, particularly that of Shale Gully. They have the same

[2] The report has been held over till now, waiting for the completion of the necessary chemical analyses.

colour as the shale in which they are embedded, although rather more greasy in appearance. In the material collected they generally appear to be homogeneous in composition without distinct shells, though the external casts left in the shale almost without exception are marked as though by a thin shell collapsing under the pressure of superimposed strata; and in a small fragment collected by Mr. Spresser, the bodies are enveloped in a white, translucent, soft, but brittle, waxy substance, one external cast exhibiting the marks of minute punctures or spiny processes. The bodies may be plant spores, but they are much like the ostracod *Cypris*; and they closely resemble those occurring in the richer shales of the Baffle Creek area elsewhere described. An animal origin would account for the otherwise inexplicably high sulphur content of the kerogen (oil-producing matter of the shales).

The Tertiaries are mostly masked by recent argillaceous deposits derived from their breaking down under exposure and subsequent recementation during the seasonal cycle. Boulders of silicified sandstone, known on the Clermont Goldfield and elsewhere in Queensland as "billy," are very abundant on the surface, but the beds from which they have been derived have not been exposed. In consequence of the scarcity of breaks in the continuity of the mantle of recent deposits hiding the Tertiaries, the structural forms of the latter are not determinable at the present time with any approach to accuracy; but it is known that the strata have been thrown into slight undulations, and exceptionally the dip amounts to as much as 45 deg. The dips observed on the shore line of that small promontory lying about a mile west of the cable crossing on The Narrows do, however, point to the existence there of a dome; and the dips at the cable-house are indicative of an anticline immediately to the east of that building. It may be taken then that the beds are structurally not unfavourably disposed for the retention of petroleum, if such has been produced by any combination of circumstances in this district, of which, however, no positive evidence is forthcoming. Brine, which is a constant associate of petroleum, has been said to occur in the smaller watercourses, and to have been met in sinking during dry weather; but none could be shown me while in the district.

The Oil Shales.

It has been common knowledge for many years that certain of the shales are combustible, blocks of such nature having been dredged from the main channel during the time that the S.S. "Premier" ran the mails between Gladstone and Rockhampton,

prior to the completion of the North Coast Railway. Some confusion has arisen in the minds of many people as to the significance of the fact that the shales on destructive distillation yield oil; for the shales have been regarded as petroliferous, whereas their carbonaceous matter (consisting, it is true, of hydrocarbons) is in the solid form.

The oil-shales vary from light brownish-yellow to dark brownish-green in colour, and are earthy to leathery in texture. They are more or less sectile, and exhibit a dark greasy streak, and all of them after exposure become fissile, besides suffering bleaching. The higher grade shale in favourable locations has been attacked at the surface by both marine-borer and white-ant, but probably to a less extent than timber would be under like circumstances. Though kerosene shale and Torbane Hill mineral are noticeably resistent to weathering, such is not the case with the low-grade oil-shales of The Narrows; and it is believed that the analyses recorded below may not represent their true composition, as all the material accessible had been long exposed to the weather. As might have been anticipated because of its having been taken from the greatest depth, the shale on the dump of the Munduran company's shaft (see C.M.L. 197) yields most oil per ton—viz., 28 gallons; and its nitrogen content also happens to be highest; the quantity being 0·42 per cent., which is equivalent to 47 lb. ammonium sulphate per ton of shale.

The Fireclays.

That the shales of Munduran Creek provide a high-grade refractory material (suitable for converter linings, &c.) also has been known for some years, and the Munduran Firebrick, Tile, and Pottery Proprietary, Limited, of Rockhampton, during 1911 actually worked deposits near the mouth of the creek.[3]

The lately-discovered clay of Curtis Island has such a composition that Messrs. Spresser and St. Ledger had no difficulty in finding a demand for it among pottery manufacturers, but they have yet to prove that sufficient quantities are available to warrant the signing of contracts. The white siliceous material of Targinie Landing Creek (C.P.A. 49) has been mined as a kaolin, but it is plainly too high in silica to be of any value as a ceramic material and besides much of it has been changed to semi-opal. Another fact not to be ignored is that the material does not seem to be present in quantities allowing of profitable exploitation.

[3] Mr. Bushnell, of Rockhampton, is said to have been the leading spirit in bringing about the commercial exploitation of the shales.

HOLDINGS.

The holdings hitherto applied for occupy but an insignificant fraction of the probable oil-shale area, wherein must be included a considerable part of The Narrows waterway.

Coal Prospecting Area 37 (applied for 5th September, 1912) is nearly three-quarters of a mile square, and includes forfeited M.L. 196, which is at the mouth of Munduran Creek. No ground has been broken outside of the leasehold (*q.v.*).

Oil Prospecting Area 44 (applied for 1st May, 1913) was intended to be 2 miles square, but from it has to be deducted any parts of C. and O.P.As. 37, 45, 46, 47, and 48, and also of C.M.L. 209, which it overlaps. The greater part of the ground held is on the southern side of The Narrows. No work whatever has been done on this holding, but there are outcrops in Shale Gully and along the shore line near the cable-house; and it may reasonably be assumed that the whole area is underlain by the Tertiaries.

Oil Prospecting Area 45 (applied for 6th May, 1913) is 1¼ mile by ¾ mile in extent, and lies to the east of the mouth of Munduran Creek, almost the whole of it being inside—*i.e.*, beneath—high-water mark. The area was secured because of the rumoured dredging of blocks of high-grade oil shale from the main channel of The Narrows some years ago; but naturally the licensees have not yet been able to embark on any scheme of prospecting.

Oil Prospecting Area 46 (applied for 6th May, 1913) is 1¼ mile by ¾ mile in area. It crosses Munduran Creek, and includes the lower part of Shale Gully, where there is an old flooded shaft—2 chains above the junction. The thin bedded shales exposed in the bank and bed of the gully have a very gentle dip (5 deg. to 10 deg.) to the westward. They are light brown or neutral tinted and slightly sectile with a greasy streak. They will probably be suitable for firebrick manufacture, besides yielding some oil. A sample (548) was taken over the whole thickness (8 ft.) exposed and submitted to the Government Analyst for chemical examination:

Proximate analysis—	%
Moisture	5·3
Volatile matter	16·0
Fixed carbon	3·6
Ash	75·1

Analysis—

Total nitrogen = 0.28 %
= 29.6 lb. ammonium sulphate per ton.

Analysis of Ash—	%
SiO_2	73·6
Fe_2O_3	3·9
Al_2O_3	20·1
CaO	0·1
MgO	0·6
Difference (alkalies, &c., and loss)	1·7

Yield of oil equivalent to 11 gall. per ton.

Specimens of the oil shales brought to Brisbane early in the year by Messrs. Spresser and St. Ledger "from a shaft near the mouth of Munduran Creek"[4] were submitted to the Government Analyst, whose finding is tabulated below:—

—	71.	72.	73.	74.	75.
Oil in gall. per ton	12·5	21·4	8·9	tr.	8·0
Sp. gr. (typical pieces) ..	1·88	1·5	1·47	1·78	1·52
Proximate Analysis—					
Moisture	7·6	6·6	7·5	5·9	7·8
Volatile matter ..	17·1	23·7	16·2	3·4	12·6
Fixed carbon	4·5	6·1	2·5	0·3	2·9
Ash	70·8	63·6	73·8	90·4	76·7

71. Light-brownish fissile shale.
72. Greenish-brown thinly laminated shale with reniform bodies.
73. Light-brown fissile shale.
74. Weathered shale from the crop.
75. Soft light-brownish shale with indistinct fossil plant remains.

The amount of the sample would give only a few cc. of oil—quite insufficient for obtaining the physical constants of fractions after distillation.

Oil does not exist as such in the shale, but the oils are merely produced in the breaking down of the organic compounds in the shale by heat.

The composition and amount of the various oils obtained depend on the rate and temperature of distillation, kind of retort employed, and similar factors. The laboratory results are, therefore, never taken as an accurate indication of oil yields which might be obtained by working on a large scale, though they are of course a useful guide in estimating the probable yield.—F. E. Connah.

Omitting No. 74, which is slightly indurated creamy clay shale with no macroscopic indication of organic contents, it will be seen that the oil yield varies directly as the volatile matter

[4] These are thought to have come from the shallow shaft in Shale Gully.

to the south, and they have been forwarded to the Government Analyst:

—	549	550
Analysis—	%	%
Moisture at 100° C. ..	2·7	4·1
Loss on ignition ..	5·5	8·0
SiO_2	75·7	56·1
Fe_2O_3	2·6	6·1
Al^2O_3	12·8	24·7
CaO	nil.	nil.
MgO	0·1	0·1
Difference (alkalies, etc., and loss)	0·6	0·9
	Some plasticity when mixed with water. Brick whitish coloured and fairly strong	Some plasticity when mixed with water. Brick reddish coloured, very strong . . . an excellent brick.
Yield of oil	..	Trace.

The object of search thus far has been a hard white porcellanous rock distinctly resembling diatomaceous earth and by the prospectors regarded as kaolin. This occurs irregularly in lumps of various sizes in the shales, particularly within a few feet of the surface. The material is snow-white, highly absorbent, and compact-earthy to porcellanous in texture, with sub-conchoidal fracture. Its hardness is much greater than that of diatomaceous earth, of which it is perhaps an alteration product.[6] Its specific gravity is low—in the neighbourhood of 2. Much of it is crowded with casts of a small gasteropod, probably a land or freshwater shell. The blocks are not at all homogeneous, many of them containing centres of semi-opal of greyish tint with a perfect conchoidal fracture, from which into the surrounding earth there is a gradual and almost imperceptible transition. The paddock contains a little over a ton, and a sample (551) of that part free of chalcedony has been sent to the Government Analyst for analysis:

Analysis—	%
Moisture at 100° C.	2·8
Loss on ignition	2·2
SiO_2	91·5
Fe_2O_3	0·6
Al_2O_3	3·6
CaO	nil.
MgO	0·1

Boulders and lumps of the material have been found also

[6] A thin slice will have to be prepared and examined under the microscope before a decision can be come to on this point.

along the western creek embedded in red and grey clayey rock, but, though much trenching has been done, the result has been disappointing, for the total quantity of the material paddocked is less than a ton.

Coal (Fireclay) Mining Lease 196 (applied for 16th April, 1909, on C.P.A. 23, and forfeited 16th May, 1912), of 25 acres. is now included in C.P.A. 37 (*q.v.*). The Munduran Firebrick, Tile, and Pottery Proprietary, Limited, was formed to work the property, and besides spending £900 thereon, installed grinding plant at North Rockhampton at a cost of £600. The firm, during 1910, carried out quarrying and shaft-sinking operations on a limited scale and from time to time sent away, in light draught boats that, taking advantage of the tides, had no difficulty in navigating Munduran Creek, cargoes of shale amounting in all to perhaps 100 tons. The shale was carried without transhipment to the works at North Rockhampton, where it was crushed and bagged for sale to the copper smelters of the district as a general refractory material, but more especially for use in converter linings. An attempt was made to manufacture brick on the ground, but for various reasons was not crowned with success.

At the present time there is not a great amount to be seen on the lease. Several feet of oil-shales crop below high-water mark in the eastern corner of the lease; and the company's shaft, the brace of which is only a few feet above high-water mark, was sunk nearby to test them. The shale beneath the surface was found to be a much darker brown, but a very few years' exposure on the brace has brought about a complete superficial bleaching. A sample (560) of the better-looking (darker) and less exposed shale in the dump at the shaft (now full of water) was collected for analysis:

Proximate analysis—	%
Moisture	5·7
Volatile matter	27·6
Fixed carbon	6·7
Ash	60·0
Analysis—	%
Total nitrogen	0·42
	= 47 lb. ammonium sulphate per ton.
Yield of oil per ton	28 gall.
Nature of oil—viscid liquid.	

Above the shaft there is a 20-ft. bank showing thin-bedded brownish shales, which have been quarried for fireclay, notwithstanding several small interbedded ferruginous bands. The shales are mostly brownish in tint, and may be expected to afford small yields of oil on distillation. The ferruginous bands

have to be picked out as the shale is broken down, but the directors of the company believe that the material is suitable for the manufacture of ochre and as such will be a valuable by-product. The shales are slightly undulatory with a tendency to drop to the westwards. Above them again the presence of plentiful well-waterworn pebbles in the soil points to the existence of a gravel bed, most likely of fluviatile origin and of comparatively recent age.

Mining Lease 209 (applied for 2nd May, 1913) is 25 by 50 chains in extent. It is on Curtis Island, on the northern side of The Narrows, the datum peg being at the cable-house.

The discovery at high-water mark of a crop about 2 ft. thick (thought by the prospectors to be 6 ft. thick) of white kaolin of extreme purity induced hopes that subsequent work has not borne out, for only 20 ft. inland a shaft was sunk 25 ft. and failed to locate its continuation in the light brown neutral-tinted shales, which it may be mentioned have a slight dip inland—*i.e.*, to the north-eastwards. It is possible that the white kaolin is a chemical residual product of the action of salt water on a certain band in the shales.

Below is given the composition as returned by the Government Analyst of a small specimen of the white kaolin brought in by Messrs. Spresser and St. Ledger. In the second column correction has been made for impurities and the result is found to agree almost exactly with the analysis (see the third column) of Anglesea kaolin as given in Dana's System of Mineralogy. An average sample (553) was taken by me of the outcropping material, as this shows some iron stains, whereas the original specimen analyses was free from such, and the Government Analyst's finding is given in the fourth column. The fifth column (554) shows the composition of the slacked buff-coloured shale on the dumps of the 25-ft. shaft:

—	1.	2.	3.	4. (553.)	5. (554.)
Analysis—	%	%	%	%	%
Moisture	7·4	..	..	5·5	8·2
Loss on ignition (water chemically combined)	13·7	15·0	13·87	13·3	8·1
Silica	42·6	46·5	46·53	41·2	55·4
Ferric Oxide	0·5	..	..	4·9	5·2
Alumina	35·3	38·5	38·93	33·7	20·4
Lime	Nil	..	..	Nil	Nil
Magnesia	Tr.	..	..	0·1	2·4
	99·5	100·0	99·33	98·7	99·7
Yield of oil	..	..	..	..	Trace

Sample 553 exhibits "some plasticity when mixed with water. Brick reddish and fairly strong and rather coarse in texture."

Sample 554 shows "some plasticity when mixed with water. The brick burst repeatedly during firing owing probably to the organic matter present. The fragments were light brown in colour and strong and close in texture."

Mr. St. Ledger assures me that a Southern firm will contract to take 1,000 tons of the high-grade kaolin at £3 10s. per ton, delivered on the wharves at Gladstone. The prospectors are naturally most anxious to prove such an extension of their find as will enable them to take up the contract, because transportation charges will be very low, as it will be possible to load the kaolin directly from the trucks into lighters on The Narrows.

CONCLUSIONS.

In review, no positive evidence of petroleum or naturally occurring liquid hydrocarbons has been brought to my notice, and while prospecting for oil by boring should not be discountenanced altogether, the field's present claim to notice lies in its carbonaceous or oil shales and its fireclays.

For the present it suffices that we have oil-shales on The Narrows; and, though these where they outcrop yield less oil and ammonia than the Scottish shales, the possibility of richer shales being found is not so remote that any method of prospecting could be altogether condemned. At the same time, it is recognised that, while there is any possibility of natural oil being discovered in Australia, capitalists are likely to be chary of investing in shale treatment works, however favourably situated, as such would inevitably fail in competition with flowing wells. The antagonism of foreign oil interests must in any case be faced; but, when full data as to the nature and thickness of the shales are to hand, it should not be difficult to decide whether the proposed industry can survive or not.

As to the fireclays, the quantities are inexhaustible, and it is hoped that the publication of the above analyses may lead to further inquiries.

Brisbane, 24th December, 1913.

APPENDIX.

The Oil Shales of Scotland.

Oil shales have been mined and distilled in Scotland since the middle of the last century; and, as the works are still productive, notwithstanding the competition of American and European natural petroleum, some light on the question of the exploitation of the oil shales of this State may be afforded by an enquiry into the conditions existing in the old country. The data required are to hand in a memoir[9] of the Geological Survey of Scotland containing a full account of the geology, methods of working, and the chemistry of the oil shales. The subjoined notes have been culled from this work.

The Scottish industry is mainly located in a belt 6 miles wide and 15 miles long, lying to the south of the Firth of Forth. In this region there are a score of well-marked oil shale horizons in the lowest subdivision of the Carboniferous System; and of these about a dozen beds are being worked, their thickness being from 1 to 12 ft. (exceptionally 15 ft.). The shales yield from 18 to 40 gallons oil with 8 to 80 lb. ammonium sulphate per ton—the latter being in inverse proportion to the former, and increasing with depth. The intervening strata in some places are being exploited also, though to a lesser extent than the oil shales proper.

"Oil-bearing shale, as known in the Lothians, is a fine black or brownish clay-shale . . . free from grittiness, often flexible, distinguished by its brown streak, toughness, and resistance to disintegration by the weather . . . and resembling hard dark wood or dry leather. . . . Its quality in the field is measured by the degree of facility with which it can be cut and curled up with the edge of a sharp knife. . . . In internal structure oil shale is minutely laminated . . . and it may graduate into ordinary carbonaceous shale."

[9] The Oil Shales of the Lothians. Cadell, Wilson, Caldwell, and Stewart. By Auth. Glasgow. 1906. See also 2nd Edition. Carruthers, Caldwell, and Steuart. 1912.

Analyses of shale from twenty seams are tabulated (p. 154), the mean being:—

Hydroscopic moisture ...	1·58 %	
Volatile hydrocarbons ..	25·17 %	
Fixed carbon	5·16 %	Sp. gr. 2·000
Ash	68·09 %	
	100·00 %	
Sulphur	1·16 %	

"The raw material . . . after being broken up by machines of special construction and subjected to destructive distillation in retorts, gives crude oil, ammonia water, and gas used as fuel."

"With the old type of retorts a shale had to yield about 30 gallons of crude oil per ton in order to be profitable, but, with the new retorts (specially designed for the manufacture of ammonium sulphate) and the increased yield of ammonia and fuel gas, a shale furnishing 20 gallons is remunerative. Not more than 16 lb. of sulphate of ammonia were formerly obtained as a maximum, now, 35 lb. to 70 lb. are got, according to the quality of the shale."

The crude oil is refined by repeated distillations and treatment with chemicals and the marketable products are:

1. Shale spirit or naphtha (sp. gr. ·660 to ·745 at 60° F.) Too volatile for safety in domestic illumination and used chiefly as solvents.
2. Burning or lamp oils (sp. gr. ·786 to ·830—aver. ·800).
3. Gas or intermediate oils (sp. gr. ·840 to ·860). Properties intermediate between burning and lubricating oils. Used for gas-making and enriching, and for cleansing.
4. Lubricating oils (sp. gr. ·865 to ·895). High boiling-point and high viscosity. Used for lubricating machinery.
5. Solid paraffin. Melting points from 100° to 130° F. Used for candle-making, &c.
6. Still coke, still grease, &c.

The ammonia water yields—

7. Sulphate of ammonia.

Since the discovery of oil in America there has been a steady decline in the number of works operating, but at the same time the total annual production has increased. Thus:

In 1871, the 51 works produced 25 mill. gall. crude oil.

In 1905, the 6 works produced 60* mill. gall. crude oil from 2½ mill. tons shale (valued at 4s. 9d. per ton).

In 1910, the 7 works produced 70† mill. gall. crude oil from over 3 mill. tons shale (valued at 5s. 6d. per ton).

* About 17½ % of the total consumption of the United Kingdom.

† About 1 % of the total consumption of the United Kingdom. Of these, three produce only crude oil.

During 1910[10] the quantity of the shale distilled was 3,130,000 tons. The crude oil produced was 273,000 tons, or 70 million gallons. The marketable products included:

Motor spirit	600,000 gallons	Total value, £2 mill.*
Naphtha	4,400,000 ,,	
Burning oil	20,000,000 ,,	
Gas or fuel oil	12,000,000 ,,	
Lubricating oil	10,000,000 ,,	
Paraffin wax	25,000 tons	
(equal to 14·7 lb. per ton shale)		
Sulphate of ammonia ...	54,000 tons	
(equal to 38·6 lb. per ton shale)		

* Otherwise the value of the refined products was only 12s. 9½d. per ton of shale.

The prices obtained in May, 1912, were as below:

Burning oil (per gall.)	8d.
Heavy oil (per ton)	£6
Refined paraffin (per lb.)	2¼d.
Ammonia sulphate (per ton)	£13 15s.

[10] Op. cit. 2nd edn., p. 139.

Anthony James Cumming, Government Printer, Brisbane.

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Queensland.

DEPARTMENT OF MINES.

Queensland Geological Survey.

(B. DUNSTAN, CHIEF GOVERNMENT GEOLOGIST.)

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THE TIN MINING INDUSTRY OF QUEENSLAND—PART II.

Geology and Mineral Resources

OF THE

Cooktown District Tinfields

(Annan River, China Camp, Mount Poverty, Etc.),

North Queensland, 1914.

With 3 Maps, 4 Figures, 59 Plates, 1 Section, and 3 Plans.

BY

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BRISBANE.

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NATIONAL MUSEUM
VICTORIA

COOKTOWN, THE PORT OF THE ANNAN RIVER TINFIELD, THE PALMER GOLDFIELD, ETC.

GEOLOGY AND MINERAL RESOURCES

OF THE

Cooktown District Tinfields.

INTRODUCTION.

The earliest officially recorded output of tin from the Cooktown tinfields was in the year 1885, when 300 tons of cassiterite were won. Whilst no very definite evidence on the point appears to be available, there seems to be good reason for assigning the discovery of payable tin in this region to about the year named.

Dr. Robert L. Jack (then Government Geologist of Queensland) inspected the fields as far back as the year 1886, and his description is contained in a report entitled "Geological Observations in the North of Queensland, 1886-7," issued in 1887 (Geological Survey Publication No. 35). Unfortunately this report, long since out of print, was not available to the writer.

Four years later Dr. Jack again visited the area, and in his nine-page foolscap report, entitled "Tin Mines near Cooktown," issued in 1891, occurs the following indication as to the date of commencement of tin-mining operations:—"Nearly four years ago I visited and reported on the tin mines near Cooktown, then in their infancy. Stream tin was being obtained in almost every gully from Mount Romeo to Mount Amos, but lode mining had just commenced on the slopes of Mount Amos." This report (G.S.Q. Publication No. 66) is out of print. It was illustrated with a geological sketch map of the country extending from a little north of Cooktown southwards to Weary Bay, in addition to which were included two sheets of plans showing the leases then in force at Lion's Den, Mount Leswell, Collingwood, and Mount Amos.

The next official report on these fields issued by the Geological Survey was that entitled "The Annan River Tinfield, Cooktown," by Walter E. Cameron, B.A., Assistant Government Geologist, in the year 1907 (G.S.Q. Publication No. 210); this now out-of-print octavo report contained a description of the

mines then working, and was illustrated by 14 plates and one map showing the locality dealt with. Mr. Cameron's report constitutes the most important and comprehensive description of these fields issued up to the present.

In 1910 Mr. Lionel C. Ball, B.E., Assistant Government Geologist, in his bulletin dealing with "Certain Mines and Mineral Fields in North Queensland," issued as G.S.Q. Publication No. 222, includes a geological sketch map of part of the Annan River tinfield; this map proved of very considerable assistance to me in the preparation of my report.

The issue of the present bulletin is in accordance with instructions issued by Mr. A. R. Macdonald, then Under Secretary for Mines, who was anxious to have prepared a complete monograph dealing with tin mining throughout Queensland. The Stanthorpe district tinfield has already been mapped in detail and described in my bulletin entitled "Geology and Mineral Resources of the Stanthorpe, Ballandean, and Wallangarra Districts (with Notes on the Silverspur Mine, Texas), Southern Queensland, 1913," with 4 maps, 4 figures, and 23 plates (G.S.Q. Publication No. 243), issued in 1914. The within report, dealing with the Cooktown district tinfields, constitutes a second instalment, whilst the detailed geological survey of the State's present most important tin producer, the Herberton district, has already been taken in hand by the writer.

With regard to the early history of the field, the following particulars, kindly furnished by one of the pioneers of tin mining in this region, Mr. Charles Ross, are of interest:—Rossville, the most important tin-mining centre at present, was named after Mr. Ross himself, he having "backed" the prospectors, Messrs. Frank Jones, Edward Starr, and John Greal, in the year 1885. He afterwards "backed" William Baird, whose blackboy, Romeo, is credited with the discovery of tin at the locality now known as Mount Romeo. Mount Hartley was discovered by James Angus about the same time as Rossville and Romeo were found, whilst Edward Bowden discovered Mount Thomas about the year 1886, which year also witnessed the discovery of tin at Mount Leswell by Patrick Finnegan. A recognition of the arduous character of the pioneering work carried out by the men named, as also of other early prospectors, is deservedly preserved in the place names of various localities where they have made discoveries, as will be seen on reference to the geological map accompanying this report.

Communication from Cooktown with the Palmer Goldfield and Tinfield (Cannibal Creek, &c.), is maintained by rail twice weekly to Laura terminus (67 miles; elevation 290 ft.), from which place the town of Maytown—once a large and important centre, but now shrunk to insignificant proportions—is distant about 50 miles, the last portion of the road to which is extremely hilly.

A horse mail (weekly) from Cooktown to China Camp (Lode Hill), *viâ* Stuckey's Gap, serves the principal tin-mining centres *en route*. Telephonic communication is badly needed between Cooktown and Rossville. A passenger coach plys usually twice weekly as far as Rossville, the single fare being about 12s. 6d.

A drawback to mining on the tinfield is the high rate of carriage charged on food and stores, these being delivered by pack-horse teams. At the time of my visit the charges per ton on goods from Cooktown were as follows:—To Rossville, £4; Romeo, £5; Slatey and Granite Creeks, £7; Grasstree, £5; Mount Poverty, £6; Helenvale, £3 10s.; Jackeroo, £5.*

The Endeavour River is available for vessels of large tonnage; but the entrance to the harbour is very narrow. Tides vary from 4 ft. to 10 ft. Depth of water at principal wharves varies from 15 ft. to 17 ft. at low water spring tides.†

The Mining Warden is located at Cooktown, whilst the Inspector of Mines for the tinfields is stationed at Herberton.

The Queensland Mineral Index (Dunstan) contains the following Proclamation of the Cooktown Mineral Field:—

"First (and only one) gazetted, 13th February, 1889, as follows:—Commencing at the mouth of the Annan River, and bounded thence by that river upwards to the junction of Oakey Creek, by the southern watershed of Oakey Creek and its tributaries, and by the northern watershed of King's Creek or New Year's Day Lagoons, and of the East Normanby River, south-westerly to the confluence of the East Normanby River and the Normanby River, by the watershed between the East Normanby and West Normanby rivers south-easterly, and a line southerly to the range forming the northern watershed of the Daintree River and its tributaries, by that range forming the southern boundary of the parish of Tribulation easterly to Cape Tribulation, on the shore of the Pacific Ocean, by the sea-coast northerly to the point of commencement;—exclusive of all reserved or freehold lands, the leased halves of Kingslake, Kingsdale, and Avoca Runs, grazing farms, and any other authorised holdings."

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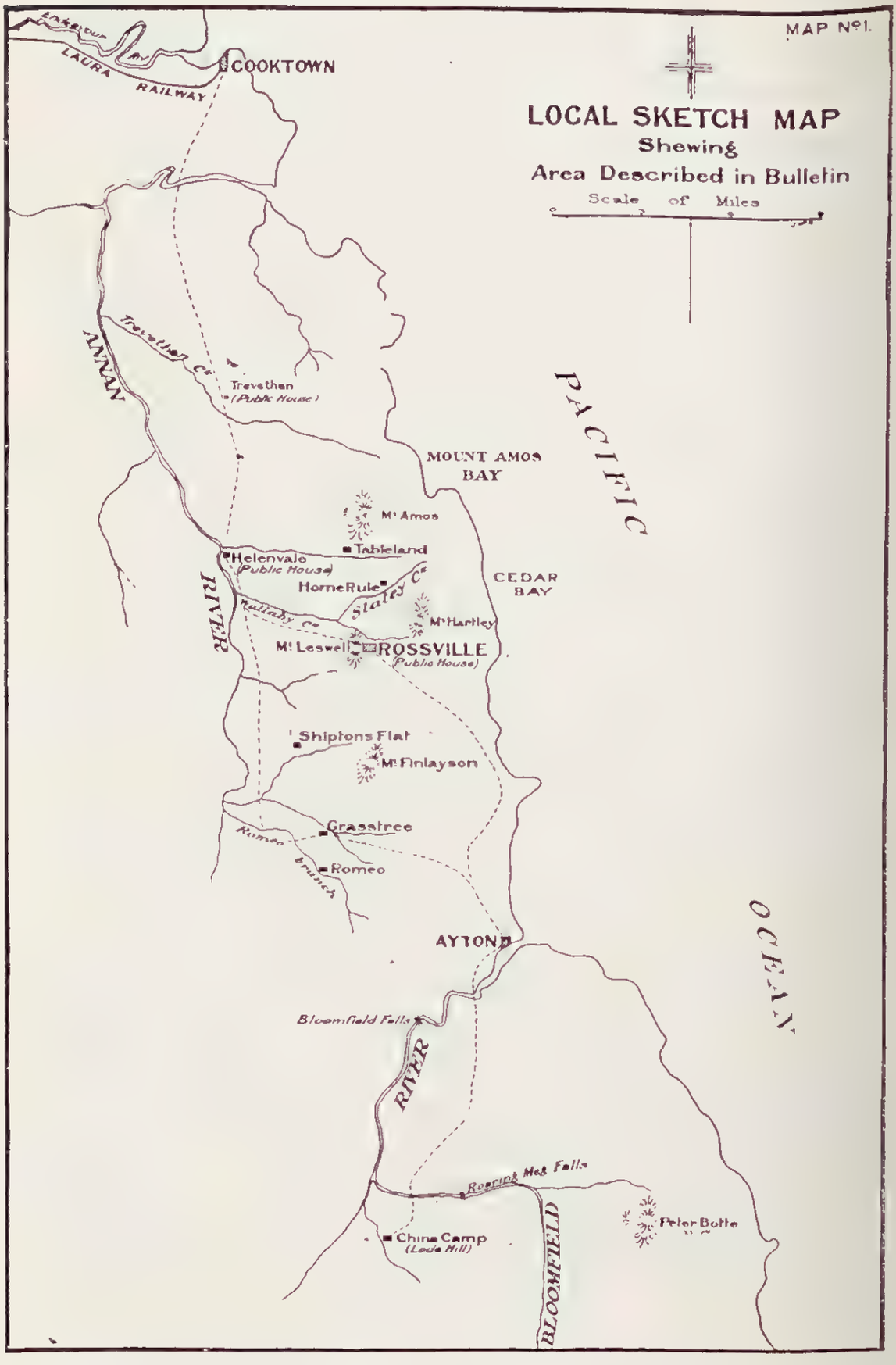
* I understand that the packers calculate a ton as being 2,000 lb. when on goods to the tinfields, but allow the full ton (2,240 lb.) on tinstone back to Cooktown.

† Queensland Mineral Index, page 297.


MAP No1.
LOCAL SKETCH MAP
Shewing
Area Described in Bulletin
Scale of Miles
LAURA RAILWAY
COOKTOWN
ANNAN
Trevethan
(Public House)
MOUNT AMOS
BAY
PACIFIC
Mt Amos
Tableland
Helenvale
(Public House)
HorneRule
CEDAR
BAY
RIVER
Mt Hartley
Mt Leswell
ROSSVILLE
(Public House)
Shiptons Flat
Mt Finlayson
Grasstree
Romeo
Romeo branch
AYTON
OCEAN
Bloomfield Falls
RIVER
Roaring Meg Falls
China Camp
(Leda Hill)
Peter Botte
BLOOMFIELD

Cooktown, which is the port for the tinfields as also for the Palmer Goldfields and Tinfields, the Starcke Goldfield, &c., is a charmingly situated town, situated on the right (south) bank of the Endeavour River at the mouth of the latter; latitude 15° 27′ S; longitude 145° 15′ E. The panoramic view of the township given in the frontispiece shows on the left the prominent hill known as Grassy Hill (560 ft. high), on which is situated the lighthouse, signalling and wireless stations, whilst the other hill—densely wooded—seen in the right centre of the picture is Mount Cook (1,400 ft.). Between these two hills is a relatively low gap leading to the splendid ocean beach at Finch's Bay, situated only a short distance from the township. The water seen in the photograph is portion of the Endeavour River, the wharves along which are situated at the base of Grassy Hill.

Cooktown takes its name from the famous navigator, who anchored at this spot in his ship the "Endeavour," which latter has given its name to the river. The tree (long since dead) to which tradition states the illustrious captain moored his ship, is still standing at a spot quite close to the present wharves. A small brass plate fastened to the tree gives details as to date, &c. A splendid monument to the memory of Captain Cook has been erected on the beach; the location of this monument has been indicated on the frontispiece.

The population of the town and district is stated to be about 3,300, of which total 1,000 are located within the township proper.

References to the climate and rainfall will be found under Chapter III., dealing with the Meteorology.

Cooktown was once a very thriving and prosperous port, particularly during the boom days of the Palmer Goldfields, but it has gradually diminished in importance until at the present time the number of business places and hotels, particularly the latter, appears out of all proportion to its requirements.

The most important mining centre is Rossville, which is connected with Cooktown by dray road *viâ* Helenvale and Trevethan, the distance from Rossville being about 27 miles, whilst Helenvale and Trevethan are 21 and 13 miles distant respectively from the port.

The area dealt with in the accompanying report comprises the region forming the upper portion of the watershed of the Annan River and its two main branches—viz., the left or Romeo

branch and the right or Wallaby Creek branch. The district mapped is roughly 15 miles in length by 9 miles in width, or an area of 135 square miles, and is situated within the parishes of Monkhouse and Clerk, counties of Banks and Solander respectively.

The field work was carried out with the aid of maps drawn on a scale of 20 chains to the inch, but in view of the lamentable lack of survey lines, the mountainous, and at times precipitous, nature of the country mapped, and the large proportion of it that is covered with dense vine scrubs, the map makes, under the circumstances, no claim to extreme accuracy, except in the case of those sections where such was possible (*e.g.*, the major part of the central portion, wherein the principal mining operations are now being conducted), but it will, it is hoped, be found as correct as the importance of the various portions of the field warrants. The approximate positions of the tracks to the various centres of the district, as also of any useful landmarks, have been indicated for the guidance of prospectors unacquainted with the field. Should this field ever attain to much greater importance than at present, the main surface features should be accurately delineated by means of a topographical survey.

PLATE 1.—A TYPICAL TINMINER'S HUT IN THE COOKTOWN TINFIELDS.

Acknowledgments.—I may here express appreciation of my former assistant, Mr. Roy Graff, for the able and ever ready assistance he rendered during the carrying out of the field work connected with this report. Certain of the granite-slate boundaries, as also of the Recent alluvium deposits, were mapped by him, whilst he also prepared for press most of the figures included in the text illustrating geological occurrences.

To Mr. O. E. Power, warden, and Mr. A. Hamilton, clerk of petty sessions, &c., of Cooktown, I am under a debt of gratitude for supplying information concerning the various holdings in force, &c.

To Messrs. E. C. Francis and J. R. Raleigh, general manager and assistant general manager respectively, of the Annan River Company, I am indebted for many courtesies in various ways, including the placing at my disposal of information and plans then available at the local office of the mine at Rossville. Also to the following gentlemen:—Messrs. A. Hedley (Home Rule), L. Solomon, Jos. Bowditch, D. Bolen, N. Bathe, M. Davies, G. Hitchcock, Jos. Bell, Geo. Goodman, H. P. Shipton, Hy. Russell, J. Wilson, D. Jones, P. S. Graham, G. Norris, J. Eldridge, W. J. Symons, R. Henderson, and others, who have rendered kindly assistance in various ways.

The maps accompanying this report have been prepared for press by Mr. F. Bryant, of the Drafting Branch, Mines Department.

Owing to the limited time available it was not found possible to visit the tinmines in the outlying districts—namely, Cannibal Creek (Palmer Field), Mount Windsor, Mount Misery, Bowden Field, Old Bloomfield Scrub, &c.

A fairly complete index has been added to permit of ready reference being made to the various subjects dealt with in the report.

CHAPTER I.

GENERAL GEOLOGY AND PHYSIOGRAPHY.

The principal block of country (135 square miles in extent) which has been geologically mapped (Map No. 2) constitutes the upper portion of the valley of the Annan River, and for the most part lies to the eastward of that stream.

As showing the rough and elevated nature of the area in question, it may be pointed out that a large portion of it stands at an average height of over 2,000 ft., notwithstanding the fact that the district is quite close to the sea—actually reaching it at Mount Amos Bay in the north-eastern section. Mount Amos (2,800 ft. above sea level) is a steep scrub-covered mountain, situated only two and a-half miles inland (due west) from Mount Amos Bay. In the extreme north-western corner, near Trevethan, is the peculiar range described below and known as Black Mountain (1,400 ft. above sea level). Mount Finlayson (3,700 ft.), distant only about six miles from the sea, is situated at about the centre of the southern section. Mount Walker is a high peak towards the centre of the area mapped; Mount Hartley is a high Peak on the eastern edge of the area at no great distance from the sea; the Tableland —a considerable area of high ground occupying the north-central portion of the area—averages 2,000 ft. in height, the "Lookout" being 2,330 ft.; the watershed (on the Mount Poverty roadway), between the Annan River and the East Normanby River, is 1,820 ft.

Mount Finlayson is the highest peak within the area mapped; it is densely covered with vine-scrub to near the summit, when this vegetation gives place to a densely-growing grey scrub known locally as turkey-bush. An excellent view is obtainable from the tops of different large clusters of granite boulders near the summit of this mountain, the yellow streak of the beach near Cairns being visible on a clear day. A rather remarkable feature that strikes one on reaching the top of the mountain is the size of the stream—Horan's Creek—within a few feet of the summit; the very copious rains, the density of the scrubs, and the joints in the granite down which water finds its way from the surface all assist in maintaining this creek with a flow which would not be usually expected at the top of the highest mountain in a district.

From the summit of Mount Finlayson the ground falls away extremely rapidly for about 3,000 ft. in vertical height to the rocky bed of the Annan River, near Grasstree.

Above Bolen's Falls, in the bed of the Annan River, near Grasstree, the steep mountain track of the river is replaced by an area so flat that Bolen's Dam (Plate 37), which is only 7 ft. in maximum height, throws the water back for 70 chains in length, but beyond the dam upstream the country becomes once more rugged, and the river assumes the character of a mountain torrent. A short distance below the falls are numerous deep holes, which have been gouged out of the hard rock bottom of the river. Two perfectly rounded pot holes about 12 ft. in diameter occur together, and are well worthy a visit by anyone in the neighbourhood. Adjoining these pot-holes is a smooth, bare rock about a chain in length along the stream channel, and this rock, known locally as "The Rock Slide," is much availed of for amusement by swimmers who sit on it and slide down into the large deep waterhole at its base.

Below Grasstree the Annan is joined on the right (north) bank at the Cooktown-Grasstree road crossing by an important tributary known variously as Parrot Creek and Pigeon Creek. The junction of these two streams is designated the Little Forks, to distinguish it from the junction of the Annan with Wallaby Creek, between Rossville and Helenvale, which latter is called variously The Forks or Nunn's Forks. Parrot Creek drains the Tabletop and Shipton's Flat tin-mining districts. A short distance below the Little Forks the Annan waters are augmented by the addition (on the left bank) of the Romeo Creek, on which latter tributary the Mount Romeo tin-workings are situated. For a considerable distance downstream below the junction of the Romeo Creek the river flows through a rough slate gorge with little or no alluvial deposit on its banks. At slightly less than a mile above Banana Flat the river commences to widen out, with the production of extensive alluvial flats, to a point as far northwards as the rapids below Helenvale described in a subsequent portion of this report. At Nunn's Forks abovementioned the Annan is joined by its main tributary, Wallaby Creek, on which latter stream is situated the village of Rossville, in the centre of the field. The last-named stream consists of the combined waters of Slatey Creek (right branch) and Mount Hartley Creek (left branch), which two creeks unite a short distance easterly of Home Rule. The amount of water flowing along Wallaby Creek past Rossville is at times certainly greater than that in the main Annan River itself above Nunn's Forks.

and it becomes a difficult matter to decide which of these two important streams constitute the main branch of the Annan proper. At Helenvale the Annan is joined by Mungumby Creek, the latter descending from the Tableland by a series of cascades culminating in Helenvale Falls (see Plates 28-33). The upper course of Mungumby Creek, above the Helenvale Falls, is known as O'Keefe's or Fitzroy Creek. The "fall" in the Annan between Rossville and Helenvale is approximately 130 ft.

Further references to the geology and physiography of this region will be found under the headings of the various mines described in Chapter II., Part 1.

The essential geological formations met with in the Cooktown tinfields, and indicated on the geological maps (Maps Nos. 2 and 3) accompanying this report, comprise the following, arranged in descending chronological sequence:—

CLASSIFICATION OF THE ROCK FORMATIONS IN THE COOKTOWN TINFIELDS.

RECENT AND POST-TERTIARY.

(1) Granite- and slate-derived alluvial deposits, occuring along the present stream channels.

Usually *stanniferous.*

(2) Older alluvial deposits occupying terraces above the present stream channels.

Usually *stanniferous.*

(3) Basalt.

Non-stanniferous *per se* but overlying stanniferous alluvial in places.

POST—PERMO-CARBONIFEROUS. (?)

(1) Diorite, quartz-diorite, &c., dykes.

Non-stanniferous.

(2) Granite and porphyry, with their associated acid dykes.

Stanniferous for the most part.

PERMO-CARBONIFEROUS. (?)

Gympie (?)

Slates, shales, volcanic tuffs, volcanic agglomerates, quartzites, sandstones, grits &c.

Rarely *stanniferous* except along the contact of the intrusive granites.

RECENT AND POST-TERTIARY.

The deposits classified under this sub-heading occupy a relatively limited area on the geological map (Map No. 2), but

viewed from the standpoint of the tin-miner, they are of paramount importance, yielding, as they have done, by far the greater portion of the tin won in this region up to the present. They consist of granite and slate detritus of all sizes from the finest silt up to the huge granite boulders which choke the beds of many of the mountain torrents. The major portion of the materials comprising these deposits are ordinary granite-derived sand, with pebbles and boulders of various kinds of granite, slate, quartzite, quartz, quartz-diorite, felspar-porphyry, &c., associated with which are usually tinstone, ilmenite, magnetite, tourmaline, and very rarely gem stones (*e.g.*, sapphires), and odd "colours" of gold.

The areas shown as being covered by this formation undoubtedly are of greater total extent than the map would suggest, but, in view of the fact that the survey was undertaken with the distinct object of delimiting the *tin-bearing* formations, only areas known to have yielded tinstone have been carefully examined. To have indicated on the map, however, all the areas where detrital tin is known to be obtainable would have resulted in practically effacing 90 per cent. of the total area of granite examined, for the mineral is of remarkably widespread occurrence, being found in small quantities in almost every square yard of soil-covered country below the many miles of slate-granite contact; in fact, it is highly improbable if any such extensive occurrence of surface-deposited tin can be seen elsewhere in the Commonwealth. The comparatively low tin contents of most of this material, added to the difficulty experienced in many instances in laying on sluicing water cheaply, as also the frequently dense scrub covering these areas, militates greatly against the possibility of successfully exploiting these superficial deposits situated on the ridges and hillsides above the stream channels.

In a few localities—*e.g.*, the site of the present workings at Home Rule, the flat to the north of Helenvale on the left bank of the Annan River near The Rapids, Better Luck claim at Mount Amos, &c.—there exist deposits of alluvial material of greater geological age than that of the Recent alluvium along the present stream channels. It is characteristic of these deposits here that the granite boulders, which must of necessity have consisted of hard rock when laid down by the then streams, have been decomposed *in situ* to material sufficiently soft to permit of being readily disintegrated by nozzle pressure.

In the case of the Recent alluvium deposits there has frequently been encountered a "false bottom," consisting of a

hard clay band—usually mistaken for decomposed slate—situated at about the normal water level of the Annan River. Good examples of "false bottoms" may also be seen on Dredging Claim 1180, above the Helenvale Hotel. At Archibald's claim at Mount Amos, Hurricane Gully claim at Three-mile, and Campbell's claim at Mount Romeo, cemented bands of pipeclay and conglomerate are considered the " bottom " for all practical mining purposes. At several of the claims—*e.g.*, Three-mile, Lorna Doone, Shipton's, O'Keefe's Creek, Tabletop, &c.—it is found an advantage to use explosives (dynamite) to loosen the tight clay overburden, thus rendering it more amenable to sluicing. At Jenkins's claim at Tabletop the washdirt has become so tightly cemented in places as to form a hard conglomerate, requiring burning and breaking up before the tin can be obtained. At Mount Poverty there occurs a bed of stanniferous ironstone conglomerate at the surface, which was worked for tin by means of very shallow drives.

A bed of older gravel is about to be mined at Saunders and Downe's Recompense claim, Mount Leswell district. The formation, which here occupies the summit of a low hill, is overlain by a thin sheet of basalt.

The extremely youthful age to which the Recent alluvium deposits may be referred is evidenced by the finding of aboriginal stone tomahawks at numerous places, including the following:—Lower Tableland (Henderson's claim), Tabletop (Spargo's claim, M.L. 234), China Camp (Lode Hill and Roaring Meg claims), Byers's Gully (Yeatman's), Grasstree United claim, &c. At the lastnamed three tomahawks were found embedded in solid washdirt at a depth of 9 ft. from the surface, whilst beds of alluvial as much as 16 ft. in thickness have been found to overlie these relics of the aboriginals.

As showing the rapidity with which alluvial deposits are produced in this mountainous country, particularly in the scrub-covered areas, by the combined action of heavy rainfall and decomposed nature of the surface formations, mention should be made of the frequent finding of copper nails, broken shovels, pick heads, clay pipes, &c., in thick beds of washdirt that have been previously considered to be virgin ground. Instances of this are common in Whitehead's Gully (Redivivus claim), in the Bloomfield Scrub.

The alluvial deposits formed along the Annan River are of notably wider extent along the right bank of the stream than

along the opposite (western) bank, steep ridges of slate frequently abutting on the water's edge in the case of the latter side.

Behind the bars of quartzite, granite, &c., which are seen crossing the bed of the Annan, the water is backed up for considerable distances upstream; in the holes so formed one might well expect to find tinstone, and it is probable that in the event of dredging being carried out in the future a considerable quantity of metal will be won from this source. Judging from the shape and extent of the alluvium deposits formed in the past along this river, the presence of hard bars must have always been a feature of the stream channel.

Along both Wallaby Creek and the Annan River are extensive areas of stream-borne material resembling sea-beaches; hence the names Riley's Beach, White's Beach, &c., applied to these recently formed shingle-covered deposits.

BASALT.

Olivine basalt, of probably Post-tertiary age, outcrops near Sikkema's, in the Big Scrub on the road from Helenvale to Shipton's Flat, notably at and surrounding the Shipton's Flat School (Reserve 18), in the south-western portion of the tinfield. From its occurrence and general appearance there can be little doubt that this and the northerly situated basalt seen at the Recompense claim (Saunders and Downe) form portion of one and the same rock mass since isolated into at least four separated outcrops by denudation. A prominent hill composed of loose basalt boulders is seen between the school and the right (northern) bank of Parrot Creek, but I was unable to trace any extension of the basalt flow across the creek.

At the Recompense claim abovementioned the basalt has been found to overlie a bed of stanniferous washdirt on the summit of the low hill above the Grasstree road, and Messrs. Saunders and Downe intend to mine this washdirt; it would appear from the dip of the washdirt seen here that the maximum thickness of basalt will be found to occupy the summit of the hill.

Post—Permo-Carboniferous. (?)

INTRUSIVE DYKES.

Apart from the aplitic and pegmatitic veins associated with the granitic rocks, several dykes of post-Permo-Carboniferous age have been observed in the area examined, intruding both the slate and granite formations.

A large dyke-like mass of diorite, striking in an approximately north-east direction, intrudes the granite near the foot of Black Mountain ridge, at a point about one mile south-westerly of the main peak. Its presence is betrayed both by the rock itself seen *in situ* and also by the dark red soil produced, the latter contrasting sharply with the grey and white soils of the enclosing granite rock.

Numerous small boulders of diorite occur through the washdirt along the Annan and its tributaries, notably at Slatey Creek, representing material denuded from dykes of this rock.

Large boulders of quartz-diorite occur in the washdirt occupying the bed of Coronation Gully, Shipton's Flat, especially at Uncle Eddie's claim; no actual outcrop of this rock, however, was seen in the area mapped.

Several dykes of a bluish green felspar-porphyry intrude the slate country along the steep track up the hill to the Phoenician workings.

GRANITE, PORPHYRY, AND ASSOCIATED ACID DYKES.

Of the 135 square miles of country, the geological structure of which is shown in Map No. 2, approximately 75 square miles are occupied by granitic rocks of various kinds.

The *granite* area extends diagonally across the field in a north-west south-east direction, by far the narrowest portion being that occupying the central section of the area examined, a width of only about 20 chains separating the slate area at the head of Rossville Creek from the large belt of slate country, including Mount Walker, lying to the westward. Owing to the extremely rugged and scrub-covered nature of most of the eastern and extreme southern portions of the field, the boundaries of the granite country, as shown, must be taken as only approximately correct.

The granite is mostly grey in colour and for the most part is of the type seen in normal biotite granite, but at times has a tendency to develop porphyritic crystals of orthoclase felspar, as in the case of the area lying to the south-east of Home Rule, to the south of the track to Mount Hartley workings. Porphyritic granite, with large, well developed crystals of orthoclase, outcrops to the north-west of Mount Leswell, forming here an exception to the general rule obtaining in this region, namely that the granite becomes progressively finer grained as the periphery of the intrusion is approached. So

marked a feature of the granite in the Annan River district is this development of a fine-grained rock along the marginal zone, that the presence of slate can often be predicted with great accuracy in areas where the latter rock is not definitely outcropping when it is seen that the granite assumes a finer grain over an extensive length. Accompanying this reduction of grain size in the minerals of which the granite is composed, is a distinct increase in the acidity of the rock; in fact, the fine-grained acid variety of the granite seen along the zone of contact would at first sight lead an observer to the conclusion that it formed a distinct intrusion, and considerable careful field examination was necessary to definitely establish the fact that it forms part and parcel of the one main intrusion. A good example of an extensive development of the fine-grained type is to be seen on the high ridge to the south-west of Helenvale, at the head of Four-mile Gully (Lower Tableland), and forming portion of the watershed between Wallaby Creek and the Annan River. Extensive areas may also be seen at the Tableland, between Mount Leswell and Baird's Creek, Collingwood district, on portion 57v, between Mulligan's Gully and Byers's Creek, near Lorna Doone claim, Rossville, and other localities. The positions of these occurrences have been indicated on the geological map, (Map No. 2).

The lower course of Four-mile Gully, Lower Tableland, is characterised by the presence of much coarsely crystallised granite possessing well-developed joint planes, the latter having a strike of 251 degrees.

Mr. Ball, in his sketch map of the field, shows the granite lying to the east of Shipton's Flat track to be "coarse-grained granular biotite granite," whilst the area still further to the eastward he describes as "very light-coloured granite, chiefly lathed orthoclase and semi-idiomorphic quartz and sparse biotite."

Of all the outcrops of granite seen in this district, there is perhaps none which equals in interest that of which the well-named Black Mountain is composed. This range is situated near Trevethan, in the north-western portion of the area mapped, on the Rossville road at a distance of 16 miles from Cooktown. When viewed from a distance this mountain has a very black appearance, due to the deposit of a very thin coating of iron and manganese oxides on the huge boulders of grey granite, of which the elevated area is formed. From a distance Black

PLATE 2.—BLACK MOUNTAIN, TREVETHAN.
Near the Coowtown-Rossville Road.

Mountain gives the appearance of a huge dyke of basic rock, and not until the hills are actually examined is one aware of the fact that they are of granitic composition. The outstanding feature of this extraordinary occurrence is the entire absence of soil on the surface, the mountain being composed of cyclopean boulders perched on top of one another, commencing at a point 400 ft. above sea level (Helenvale is 330 ft.), and continuing to the summit at 1,400 ft.; huge holes are abundant over the surface of the mountain, representing spaces between groups of boulders leaning against each other. The very severe task of scaling this range was successfully accomplished by my assistant, Mr. Graff, and myself, but I have no desire to renew the visit to the summit. The granite boulders maintain about the one size throughout, and would appear to have been formed by the exfoliation of blocks produced by three sets of master joints through the originally solid rock mass. The rock must be composed of constituents which are readily carried off in solution; otherwise soil would be produced by reason of their weathering. Not a vestige of soil remains over many acres of these piled up boulders, nor is there any appearance of any quantity of soil having formerly existed here and been since removed by denudation. The absence of soil causes the rock to give off a peculiar metallic ring when struck. Towards the summit of the ridge we heard a deafening noise set up by countless frogs; this fact indicates the existence of water among the boulders at no great depth below the surface. A prominent rock on the summit towards the Cooktown road is locally known as the "Pillar Box," from a resemblance to that article; it constitutes a prominent landmark. The road between Cooktown and the tinfields crosses this ridge at a low gap some 500 ft. above sea level. The accompanying photographic view (Plate 2) will give an idea of this most interesting and unique occurrence.

In consequence of the expansion and contraction, due to heat and cold, the great granite boulders here often become shattered, at times with explosive violence and accompanied by a noise as of cannon.

A very abundant mineral throughout the granites in this area, and more particularly where the latter is stanniferous, is dark-coloured tourmaline. A detailed description of the various occurrences of this mineral here are given in Chapter II., Part 3.

Pegmatite veins (tourmaline-bearing) have been noticed at McLean's claim, Rossville; also at the Fitzroy Bar on O'Keefe's Creek, Tableland, and elsewhere.

Small isolated intrusions of granite into the slate country may be seen at several places, including the bed of the Annan River at Helenvale, a short distance west of the Little Forks, on the track from Collingwood to Mount Leswell, &c. The presence of these small intrusions into the slate country tends to indicate a dome-shaped surface to the main granitic boss, the upper portion of the dome being represented by the area occupied by granite at the present surface.

Several quartz veins in aplitic granite are to be seen near McLean's Camp, close to the village of Rossville; strike N20°W, and a second set striking E20°S. Those veins striking easterly are here later than those exhibiting a northern strike, and in several places have distinctly faulted the latter.

Veins of sericitised *aplitic granite* intrude the slate country at Uncle Eddie's Show, Shipton's Flat, and appear to there be closely connected with the genesis of the tin deposits.

Near the north-eastern corner of the Bright Smile claim at Mount Hartley a granite dyke intruding slate country has been opened up in order to expose a small tin-bearing reef of sugary quartz with tourmaline and a little sericite; strike, north and south. In the same district another dyke consisting of bluish-coloured aplitic greisenised granite intruding the slate country constitutes the ore-body of the Caledonia tin lode; strike, roughly, north-west.

The existence of a seam of soft, fine-grained micaceous tourmalinised granite traversing the tin lode in slate at Norris' lode, Mount Amos, is of interest, owing to the peculiar nature of the tinstone by which it was accompanied (*vide* Chapter II.)

The principal intrusions of *porphyry* mapped occupy the extreme western portion of the area. Westwards of Baird's Creek, and crossing the Annan River, a large dyke of porphyry is met with. This dyke, which intrudes slate country throughout its exposed length, extends for a total distance of 1½ miles, the major portion lying to the southwards; at its extreme southern end this dyke closely approaches the Grasstree road near Saunders and Downe's workings. In its central portion it is inclined to be porphyritic, but the peripheral zone is extremely acid and fine-grained in type, and may be described as felsitic. The dyke would be classed as a quartz-porphyry, though in some places it is difficult to distinguish it from a granite. No tin or other commercially valuable metallic deposits appear to be genetically connected with these intrusions.

Three-quarters of a mile north-westerly of the above-mentioned dyke a still larger intrusion is seen outcropping at the river edge and continuing up the slate range for a distance of at least a mile, forming a very prominent outcrop and constituting the backbone of the top of the steep ridge overlooking the Annan. Where seen at the river it contains very large orthoclase felspar crystals—up to 2 in. in length, and frequently twinned on the carlsbad plan. The strike of this dyke is the same as that of the first one described, and it may well be that it forms a continuation of the same intrusion, the upper surface of which departs from a plane, with the production of elevations and depressions, the elevations alone actually outcropping. A small dyke of similar rock intruding slate occurs a short distance to the north of the second dyke, and possesses nearly the same strike.

Small porphyry dykes in slate country, striking north-west—south-east, cross Parrot Creek, midway between Shipton's Flat and the Little Forks, whilst a small dyke having a north-south trend also intrudes slate in the centre of portion 38v in the same district.

Dykes of intrusive granite and porphyry can be seen traversing the quartzite bar through which Spargo's tail race has been shot at Tabletop.

Numerous large boulders of quartz-felspar porphyry occur along the granite bottom at Davison's Gully claim, Three-mile, and also at McAuliffe and Bannon's claim on Darby's Gully, Mount Hartley district; in both instances it would appear as though the boulders in question represent blocks from dykes intruding the granite country, and hence the porphyry intrusions are probably of post-granitic age.

On the ridge above the No. 1 face at the Coronation claim, Mount Romeo, occurs a bar of hard aplitic granite, and the best tin values have been found down the slope from this formation.

Permo-Carboniferous. (?)

Slightly less than one-half of the area mapped is occupied by sedimentary formations, whose greatest development is seen in the western and eastern portions of the field. These rocks comprise slates, shales, volcanic tuffs, volcanic agglomerates, quartzites, quartz-sericite schists, sandstones, grits, &c.

Regarding the question of their exact place in geological time, no data sufficient to definitely establish their position has

so far been obtained, hence in the present report the previously adopted assignment of these rocks to the Gympie formation has, in the absence of further evidence, been adhered to.

No fossil forms whatever have been recorded from these rocks. They would appear to occupy a position between the coal-bearing strata of the Cooktown district and the auriferous schists of the Palmer Goldfield. Owing to the great amount of metamorphism induced in them by the granitic intrusion, lithological characters are of little use in arriving at an estimate of their geological age; rocks in the New England, New South Wales, tinfields, which from their appearance were usually considered to be of at least Devonian age and probably older, have now been definitely proved (by fossil evidence) to be of Lower Marine age. There is a very great similarity of appearance between the last-mentioned rocks and those seen at Cooktown.

Several hard bars of blue slate cross the Annan River at intervals; these bars appear to owe their hard character to the metamorphism induced by the hydrothermal and indurative action of adjacent porphyry and granite intrusions. The slate areas are frequently tilted by the intrusions, but, as may be expected, the strikes of the different masses are by no means regular.

About one mile south-west of Nunn's Forks, on a high ridge, there occurs a prominent bouldery outcrop of silicified sediments, comprising agglomerates, conglomerates, sandstones, &c.

The contact zone between the slate and intrusive granite is usually characterised by the production of extremely hard rock, and where the contact is crossed by streams the latter have been generally unable to cut their way down, with the result that numerous waterfalls and cascades have originated. Home Rule Falls, Helenvale Falls, the falls along O'Keefe's Creek, on the Tableland, those on portion 54v, and the reserve to the southward thereof on Upper Trevethan Creek, Poulsen's Falls, Jones's Creek Falls, Romeo Falls, the Bunks Falls, and many others could be cited as instances of the hard rocks produced along and adjacent to the zone of contact. The slate-granite contact is often coincident with stream channels—*e.g.*, O'Keefe's Creek, Jones's Creek, Mount Hartley, Mount Amos, &c. The rock produced is usually a hard bluish quartzite seamed with tiny veinlets of quartz. Except for its excessive hardness this rock might easily be mistaken for a fine-grained basalt—*e.g.*, at Sinclair's Gully.

A band of quartz-sericite schist, striking at an angle of 255 degrees, may be seen in the slate country on portion 39v, just

south of Mungumby Creek, Helenvale district. Another large band of this rock crosses the Cooktown to Grasstree road a short distance on the Cooktown side of the Little Forks (Annan River) at the rough ridge known as Rogan's Folly.

Along the northern edge of Mungumby Scrub, Helenvale, at a point on the Cooktown road, half a mile north of the Lion's Den Hotel, there occurs an outcrop exposed by the road cutting of very highly cleaved and schistose rocks containing a fair amount of chlorite; strike, north-north-west; dip, south-west.

In Three Jims Creek, about 1½ chains below the track from Rossville to Ayton through the Bloomfield Scrub, the junction of the slate and granite is clearly visible, running north-west south-east. The intrusion of the granite into the sedimentary formations has here resulted in the alteration of the latter into quartzite, whilst the granite itself along its periphery assumes a fine-grained quartzose character, and is extremely hard, resulting in the production of a small cascade at this point.

The slate-granite contact can also be clearly seen in Jones's Creek about half a mile upstream from its junction with Wallaby Creek. The granite is here very fine-grained along the periphery. The sedimentary formations are dense hard, blue, fine-grained quartzites, which, upon decomposition, give rise to a characteristic reddish-coloured soil, the whole formation very closely resembling basalt both as regards the appearance of the rock and also in the resulting red soil. The line of contact is here practically coincident with the creek bed, the stream having naturally worked its way down along this less resistant line in preference to incising a bed for itself across either the excessively hard granite or quartzite. The quartzite is markedly jointed (irregularly) and breaks up on weathering into fragments the size of road metal. The sedimentaries here occupy the right (east) bank of the creek. Numerous thin tongues of aplite traverse the last-named rock and contain fragments of partly corroded quartzite disrupted during the intrusion of the granitic rock. The upper surface of the granite underlying the quartzite suggests that the surface of the former is comparatively level.

Except along the contact with the intrusive granite the slate is very rarely stanniferous; a little crystallised tinstone is frequently deposited along joint planes in the slate near the contact, and a small tin-bearing lode—Norris's—was worked some years ago in slate country at Mount Amos.

CHAPTER II.

ECONOMIC GEOLOGY.

PART I.—THE MINES.

The stanniferous deposits of economic importance at present being exploited on this field may be divided into:—

(*a*) Alluvial deposits; *e.g.*, Annan River, &c.

(*b*) Lodes; *e.g.*, Mount Amos, Mount Leswell, &c.

(*c*) Contact deposits; *e.g.*, Annan River Company's deposits at Daly's Face and Collingwood, Lode Hill, Coronation Claim at Romeo, &c.

In the accompanying description of the various mines, the plan of keeping the different deposits under the heading of the locality, rather than to attempt to classify them according to the nature of the deposit, has been followed.

Rossville.

Annan River Company, No Liability.—Registered office, S. J. Warnock, 375 Collins street, Melbourne; general manager, E. C. Francis; assistant general manager, J. R. Raleigh,* Cooktown representative, Charles Patching, solicitor and attorney.

The operations of this company constitute by far the most important of any being conducted in the area comprised within this report, both as regards the quantity of ground to be treated and also the capacity of the machinery installed for that purpose.

The areas held include Mineral Lease 218 (80 acres), Dredging Claim 1114 (96 acres 2 roods 14 perches), Dredging Claim 1183 (100 acres), Machine Area 21 (5 acres), together with several leases at Collingwood Hill to be referred to subsequently.

Work is being carried on mainly on the northern portion of M.L. 218. The material being treated here consists of decomposed stanniferous greisenised tourmaline granite, adjoining the slate-granite contact. The upper portion of this material had previously been sluiced to a shallow depth, when a considerable amount of tin was obtained. This material represented a surface concentration due to the disintegration and partial denudation of the granite by sub-aerial agencies, and naturally diminished rapidly in tin values with depth. When subsequently it was

*Mr. Raleigh has since been appointed General Manager.

discovered at the Lode Hill property on the Bloomfield River that the underlying granite contained payable tin values, and was also sufficiently decomposed to permit of treatment by sluicing methods, the ground now held by the Annan River Company at Rossville was found to contain a similar deposit, and was opened up and extensively tested by Mr. Francis by means of both boring and actual sluicing of paddocks. Upon the tin values and quantities thus disclosed a strong company was formed in Melbourne, with the object of handling the proposition on a scale of sufficient magnitude. The failure of the Collingwood race to supply an efficient water service for more than about six months in a year, led the directors to decide upon the installation of a powerful pumping plant to make up the deficiency and thus enable sluicing to be carried on uninterruptedly.

Plate 3.—Dense Scrub above the Annan River Company's Pumping Station, Rossville.

In order to arrive at a reliable estimate of the tin values, continuous prospects of the material raised during boring were washed; then the total returns were assayed for metallic tin and the contents as tinstone calculated back therefrom. This method does away with the error arising from the inclusion of black sand with the tinstone, as often happens when the tinstone itself is merely weighed, it being practically impossible to remove all impurities from a sample of fine-grained tinstone concentrates by the ordinary mechanical methods.

Water for sluicing is being obtained both from the Collingwood race (referred to below) and also by pumping from

Wallaby Creek at a point about six chains above the junction of that stream with its left bank tributary, Rossville Creek (Machine Area 18).

The PUMPING PLANT, which is one of the most up-to-date type and of very great capacity, was only quite recently installed.

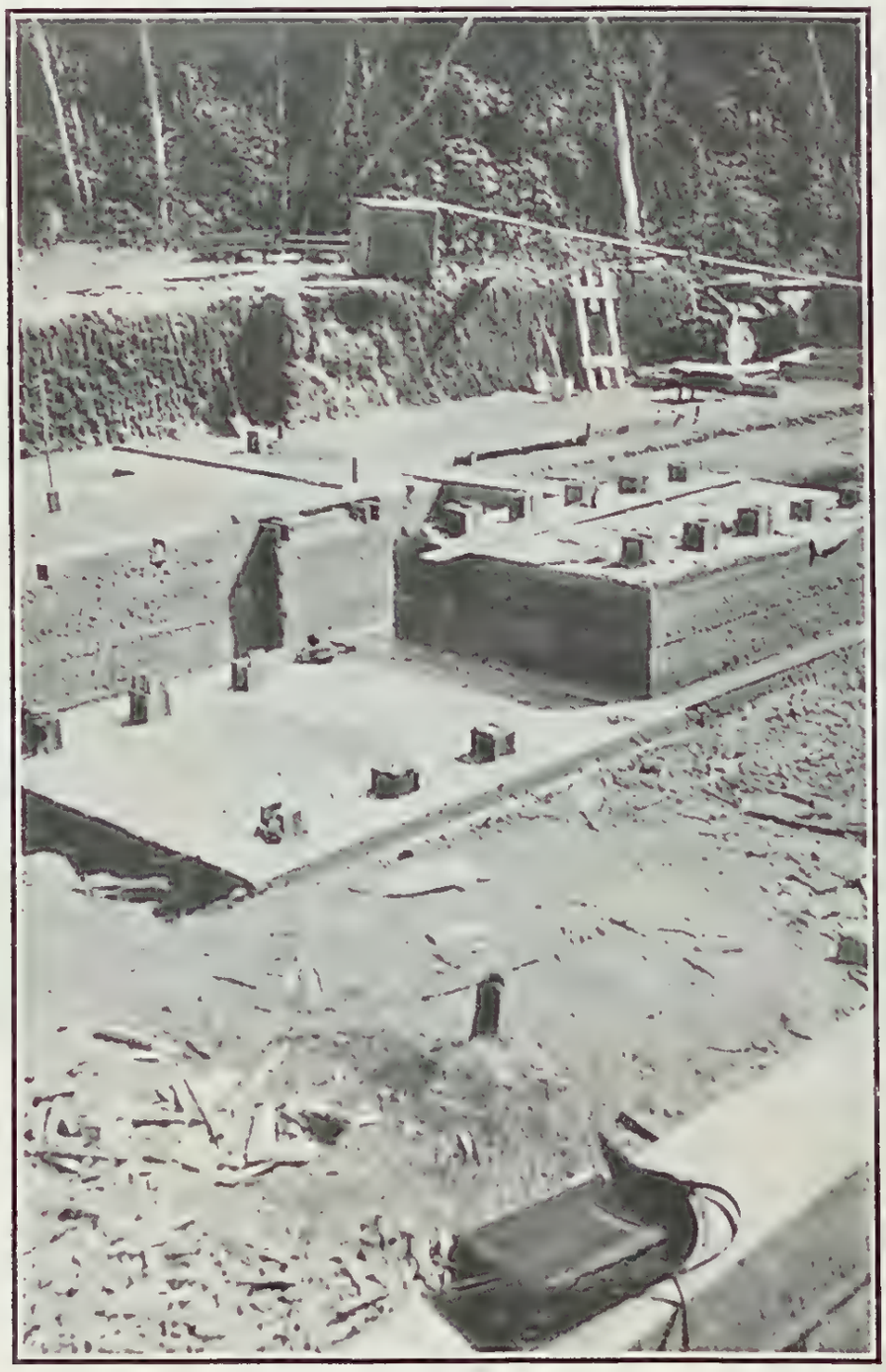


PLATE 4.—CONSTRUCTING THE CONCRETE FOUNDATIONS FOR THE PUMPING PLANT, ANNAN RIVER COMPANY.

The following description of the machinery in use here will give an idea of the magnitude of the plant (made by the well-known firm of mining machinery engineers, Messrs. Thompson and Co., of Castlemaine, Victoria). Triple expansion quick

revolution surface condensing engine of enclosed type, having 12½ in., 18½ in., and 29 in. cylinders and 12 in. stroke; forced lubrication; direct coupled to a four-phase centrifugal pump. Steam is supplied from a Babcock and Wilcox boiler, with 2,530 square feet of heating surface, and is delivered to the engine at a pressure of 180 lb. and at 150 degrees of superheat. With steam as stated and running at 400 revolutions per minute, the engine is capable of developing 570 horse-power, and through the pump is guaranteed to deliver 4,000 gallons of water per minute against a total head of 317 ft.

The pipe column is constructed of 20 in. diameter spirally riveted pipes of 10, 12, and a few of 14 gauge; its length is approximately 6,000 ft., and at the point at which it is connected on to the paddock pipes is 140 ft. (vertical) above the intake at the pumping station on Wallaby Creek. The pipes used in the columns at the paddock are of 16 in. diameter, having telescope joints and lugs. The nozzle is fitted with 4-in. and 5-in. brass tips, the water being pumped direct through the nozzle.

PLATE 5.—TEAMS LEAVING COOKTOWN WITH PIPES FOR THE ANNAN RIVER COMPANY, ROSSVILLE.

At the head of the sluice boxes a "grizzly" of reversed type, 10 ft. wide, is being installed, the grizzly bars being set at such a width apart that all stones above 1¼ in. fail to pass through, and are delivered into a chute, from which latter they are trucked away to a convenient dumping site. The bars of which the grizzly is constructed are each 5½ in. in length and of tapered section (⅝ in. at the top, diminishing to ¼ in. at the bottom); they are set at an angle of 42 degrees.

After passing through the grizzly the sands flow through a short sluice box 11 ft. in width; the fluming then gradually widens out in a length of 1 chain to a width of 37 ft., made up of two 16-ft. sluice boxes and a central compartment 5 ft. wide, the latter being a decided convenience as it will be used for the purpose of receiving the partially cleaned tin concentrates without in any way interfering with or causing a cessation of sluicing operations. The boxes maintain their maximum width of 37 ft. over a length of 4½ chains, which length it is intended to still further increase in the future; they are set on a grade of 6 in. in 12 ft., or 1 in 24.

The sands, after passing through the sluice boxes, will pass down a tail race, 10 ft. wide, tapering off from the main boxes and leading to a sump hole, from which it will be elevated by a gravel pump and delivered in a vertical height of 50 ft. through 300 ft. of heavy weldless steel pipes 16 in. in diameter. The tailings will then pass through 12 chains of discharge race into a gully depression beyond the ridge to the east of the workings.

The GRAVEL PUMPING PLANT (also supplied by Messrs. Thompson and Co.) consists of a quick revolution compound surface condensing engine of 350 horse-power, operating at 380 revolutions per minute; 13 in. and 22 in. cylinders and 10 in. stroke. The engine is direct coupled to the gravel pump by means of flexible coupling. The gravel pump is of 14 in., with a runner having a diameter of 3½ ft. Steam is supplied by a Babcock and Wilcox boiler of 1,433 square feet heating surface, and fitted with a superheater of 270 square feet and steam at 180 lb. pressure. It is estimated that this plant will deliver 80 cubic yards of tailings per hour to the required height. Both the engine in use here and also that at the pumping station on Wallaby Creek, by suitable connections and butterfly valves, may utilise practically all the water pumped for condensing purposes.

A lighting dynamo, direct coupled to a quick-running engine of 700 revolutions per minute, is installed at the gravel pump station.

A "waterway," 75 ft. long, has been constructed to the pump hole at the main pumping station from Wallaby Creek. This tunnel is 4 ft. 6 in. in width and 4 ft. deep; 1,000 superficial feet of sawn timber was used in this work, the passage being close timbered with close sets and then lined with boards.

The construction of this waterway occupied a fortnight, but the cost has been more than balanced by the efficiency of flow assured to the pump.

Owing to the dampness of the climate and the difficulty of obtaining accommodation for the workmen close to the property, the manager has erected a row of very comfortable rooms, as men's quarters, near the sawmill, an arrangement which is much appreciated by the employees.

A dam of large capacity has been constructed on Angus Gully, close to the gravel pumping station, for the purpose of supplying clean water to the boilers at that and the main pumping station at Wallaby Creek.

PLATE 6.—"GRIZZLY," TILL LATELY IN USE AT THE ANNAN RIVER COMPANY'S CLAIM, ROSSVILLE.

It is intended also to construct a BUCKET DREDGE to treat the large amount of alluvial deposit occurring along Rossville Creek, Wallaby Creek, &c. I am informed that this plant, which is being supplied by Charles Ruwolt Proprietary, Limited, of Richmond, Victoria, will comprise the following:—

Two pontoons each measuring 94 ft. long by 34 ft. in width; to be built of local hardwood, the planking being 12 in. by 2½

in. and the upper framework, to support the gear, &c., to be from 14 in. to 12 in. and 10 in. The corners of the pontoons are to be sheathed with steel plates.

A 25-h.p. engine will be used for the purpose of driving the pump, buckets and screen. Steam will be supplied from an internally fired boiler working at 140 lb. pressure. A small engine is to be installed for the task of handling a winch having seven drums; this winch is necessary for the handling of the pontoons and the gear.

The bucket ladder is to be 48 ft. in length, and capable of dredging to a depth of approximately 15 ft. below water level; the buckets will be 30 in number and of 5 cubic feet capacity in each case.

The tin-saving appliances are to include a revolving screen 26 ft. in length and of 5 ft. diameter, with $\frac{3}{8}$ in. punched holes.

The boxes will be 76 ft. long, in 6 divisions of 4 ft. wide, and constructed of mild steel plates.

A centrifugal pump (Tangye's) is being added in order to supply water to the screen and launders.

The dredge is to be fitted up throughout with electric light.

It is estimated that this plant will require about 90,000 superficial feet of timber, and will weigh approximately 100 tons.

The owners consider that they will be able to treat 35,000 cubic yards per month with this dredge.

Owing to the cost of landing on the site the huge quantity of timber required in the construction of the bucket dredge, the sluice-boxes, buildings, &c., the company decided to erect a sawmill for themselves on the ground. The trees taken to the mill comprise several varieties of oak, pencil cedar, hickory, scrub ironbark, sovereign wood, teak, &c., the Rossville district containing a great quantity of good scrub timbers of all kinds suitable for mining requirements. The accompanying photograph (Plate 7) gives a view of the sawmill mentioned.

The rainfall recorded here for the twelve months ending 31st December, 1914, was 128·92 in.

It is intended to conduct operations in the future by sluicing, in one extensive face, the whole of the northern slope of the hill embracing the various present faces. At first the decomposed granite, &c., will be sluiced away till the bottom of the cut is at about the same height as that of the recently constructed sluice-boxes (140 ft. above the pumping station), after which the

material still remaining to be treated below that level will be raised to the height of the boxes by means of a large gravel pump.

The most important of the present working faces is that known as Daly's (150 ft. above Wallaby Creek), occupying the southern portion of the workings, where an immense opencut has been made on the slope of the hill by means of nozzle pressure supplied by the Collingwood race. The yield of tinstone from the open cut is stated to have averaged 1½ lb. per cubic yard. This amount, taken in conjunction with the immense quantity of

PLATE 7.—THE SAWMILL, ANNAN RIVER COMPANY, ROSSVILLE.

material remaining to be treated, is considered by the owners to allow a margin of profit sufficient to warrant the expenditure of the very large sum laid out by them on the pumping machinery described above. The evidence available up to the present points to a very even distribution of the tin values through the granite at this face.

A notable amount of tourmaline sand accompanies the tinstone, but is easily removed during streaming operations.* The tinstone sold from here has assayed from 72 to 73 per cent., with a limited quantity of lower grade ("seconds") assaying at least 65 per cent. The impurities present in these "seconds" are mainly specular iron ore and ilmenite, but it is stated that no deleterious substances are present in the tin as sold.

Arsenical pyrites occur in the form of small isolated seams and masses through the granite, and also at times accompanying quartz leaders and quartz-tourmaline veins. Nuggets of this

* The specific gravity of tourmaline is 2·98 to 3·20, as compared with that of tinstone, which latter is 6·4 to 6·7.

mineral are found when streaming; they exhibit a very curious surface that has often caused the substance to be mistaken for a smelted product at first glance.

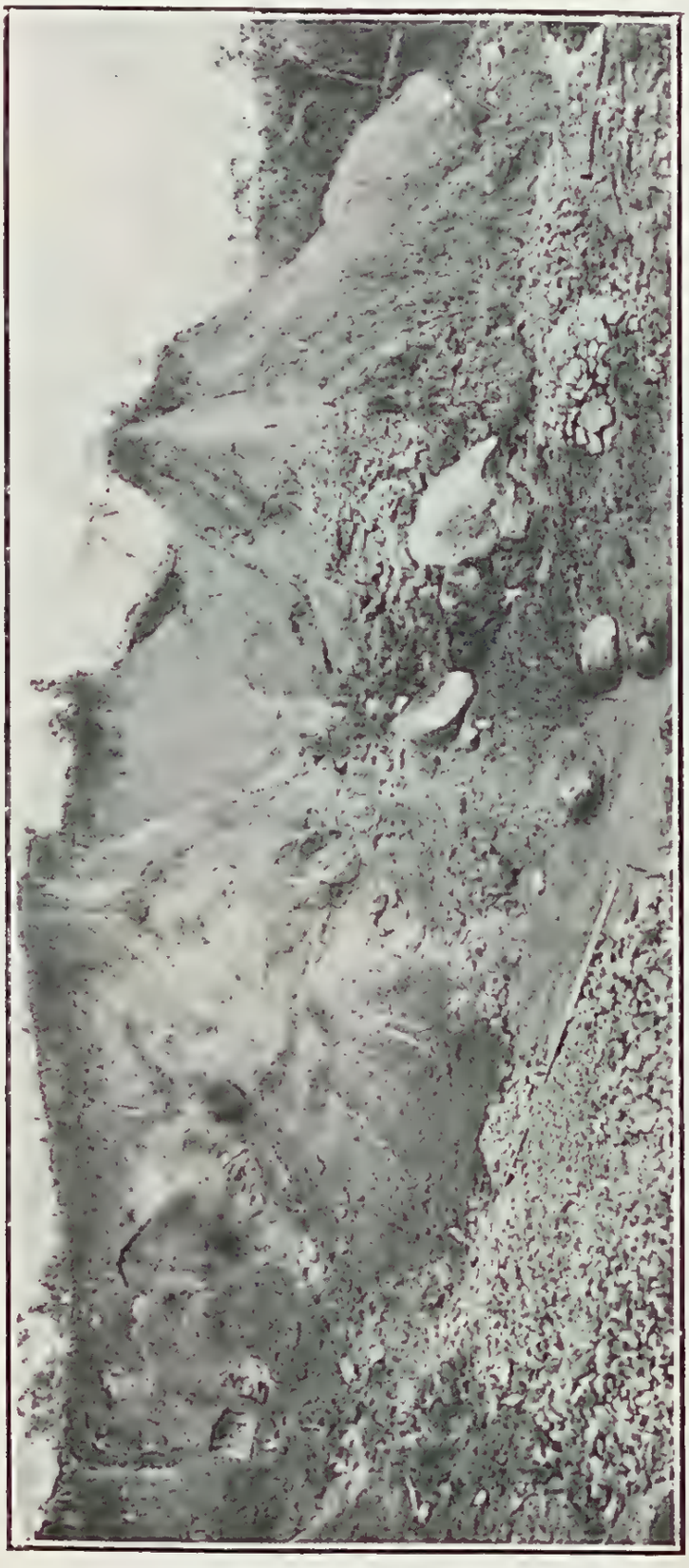


PLATE 8.—DALY'S FACE, ANNAN RIVER COMPANY'S CLAIM, ROSSVILLE.

Practically the whole of Daly's Face is in granite, the maximum depth of this formation being seen along the southern end

of the cutting, where a total thickness of at least 100 ft. is seen. A large ridge of comparatively hard granite occupies roughly the central portion of the open cut, striking north and south. Slate (very decomposed) is making its appearance along the western corner of the cut and beyond this point in a southerly direction (up the ridge). The total tin values from the surface downwards revealed by boreholes over this section of the area are poor, though the underlying granite itself may quite possibly carry payable values.

Very extensive systematic boring and shaft sinking has been carried out over this deposit by the present holders, with, it is stated, such satisfactory results that the future of the property is assured, but the plan showing the values as disclosed by these boreholes was not available at the time of my visit.

I am informed that the boreholes were of limited depth only, as compared with the total thickness of material known to exist here, owing to the quantity of water encountered at a depth; casing has, however, now been obtained, with the assistance of which it is intended to commence a further vigorous prospecting campaign early in 1915, following indications on the outskirts near pilot bores, which have already indicated the existence of tin values, and to prospect a limited number of holes to a depth of say 100 ft.

Boreholes have been sunk to a depth of 40 ft. below the present bottom of the open cuts, as well as from the natural ground surface, and the results are stated to point to the existence of a great total depth of payable material of a sufficiently decomposed nature to permit of treatment.

Through the central mass of relatively hard rock running through the middle of the face are very numerous quartz veins of a brownish colour. It is of interest to record that in the case of all the areas worked so far the richest ground has been distinctly redder in colour than elsewhere, due probably to the very close proximity of slate either *in situ* or denuded off at no very distant period.

At Daly's old workings, situated on the ridge to the north-west of Daly's Face, a very rich surface deposit of tin was worked some years ago by sluicing this material, and a large quantity of tin obtained by the then owners.

I am informed by Mr. Francis that he carried out very careful sampling of the " forkings," &c., obtained during sluic-

ing, but the percentage yield of tin was far too low to warrant their treatment by a battery. The same result was obtained under similar circumstances at Lode Hill.

Rich tin values are stated to exist in the alluvial along the sides and bottom of Angus Gully, a right bank tributary of Rossville Creek, a short distance easterly of the main workings. From the foot of B Face, around the sluice boxes, and also over the flat adjoining, there exists a considerable area of payable alluvial material resting upon slate country mainly. This ground is said to carry 2½ lb. of tinstone per cubic yard, and the company intend at some later date to treat the material by means of the gravel pump.

A borehole 40 ft. below the bottom of B Face gave payable values all the way down, whilst the granite passed through was sufficiently decomposed to allow of being readily sluiced. The contact of the slate and granite passes through the property near the centre of this open-cut, the slate being highly decomposed and showing itself by the clayey red material into which these sediments frequently decompose in this region. The maximum depth of decomposed granite exposed here is 50 ft.; the whole of the material was very decomposed. The upper surface of the ground surrounding B Face was removed some years ago, with payable results, this material here resting upon decomposed slate, which rapidly gives place in depth to the granite.

At what is known as Glass's Face a small circular area has been sluiced out to a depth of 25 ft. from the surface; the bottom of this working place is of relatively hard rock in places, and is traversed by numerous broken quartz leaders striking N. 30 degrees W. and dipping W. 30 degrees S. at a steep angle. The whole of this rock material is apparently within granite; some of the leaders aggregate 18 in. in width and contain a moderate quantity of tourmaline. The quartz is brittle and mainly granular in structure. Borings along the edge of this cutting, as also samples from the banks of the small gully running from the northern end of Daly's Face into Angus Gully, are stated to indicate the existence of payable values over this area. Beyond this gully the values are poorer, but better returns have been obtained from the scrub country lying to the east of these workings. It is intended to bring the working tail race up through the B and Glass's Faces.

A considerable area of alluvial exists between the men's quarters near the sawmill and the old fruit garden in which the engineer's residence is situated.

The depth of the red clay alluvium exposed along the tail-race till recently in use from Daly's Face is about 10 ft., but it is probable that the central portion of this flat will ultimately prove to be about 16 to 20 ft. in depth. The bottom of the race is in slate of a moderately decomposed character; small intrusions of tourmaline granite similar to those seen in Daly's Face occur through the slate, and it is therefore practically a certainty that tin values will be found here in the underlying granite should it ever be deemed expedient to strip the thin slate formation after the alluvium has been removed. At intervals along this tail-race thin bands of gravel are intercalated with the red clay seams.

In the sluice race through the centre of the main workings occur numerous parallel veinlets, in close proximity, of brittle brown quartz striking N. 20 degrees W. Through the bedrock along the eastern edge of the north-south ridge of partly decomposed granite in the centre of Daly's Face there occurs a large number of quartz veinlets striking N.W. The production of these veinlets has been preceded by the intrusion of a dark grey rock closely resembling a decomposed quartz diorite at first sight, but actually representing basic segregation, occupying fissures through the granite and containing very abundant fine-grained tourmaline. This dyke-like rock is of very even grain; its occurrence is identical with that seen in many intrusive dykes, namely, lying along a definite strike (here E.W.) in the form of

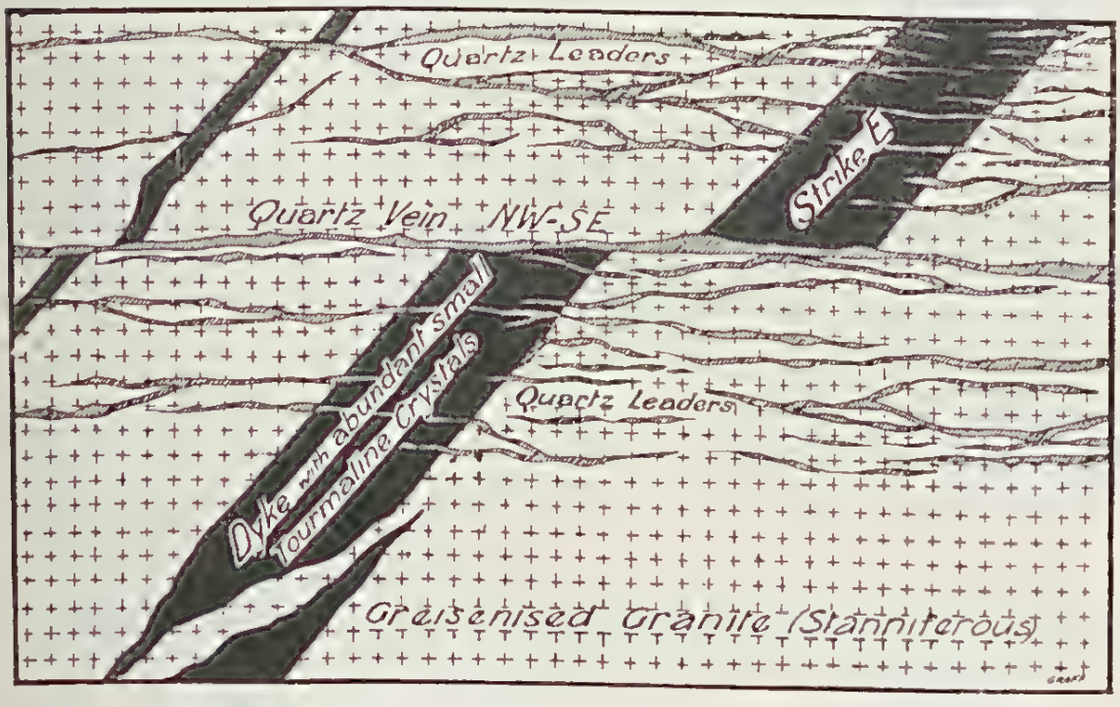


FIG. A.—SEGREGATION DYKE CONTAINING ABUNDANT TOURMALINE.

Showing faulting by Quartz Veins, Daly's Face, Annan River Company's Claim, Rossville.

narrow lenses disposed *en echelon*. Its eastern extension (decomposed)—into the wall of Daly's Face is clearly marked by a light coloured band in the granite. The dip, as shown at this face, is roughly 60 degrees. Its western extension into the harder granite mass of the central ridge is of interest, in that it has been distinctly faulted by the quartz veinlets abovementioned, the displacement amounting to 1 ft. to the north. The effect of the quartz veinlets has been to bring about secondary silicification of the tourmaline-bearing rock. The accompanying drawing (Figure A) illustrates this somewhat unique occurrence.

A second smaller vein of similar tourmaline-quartz rock occurs about 9 ft. to the south of the main vein, and is likewise faulted in part. The quartz appears to have been deposited along very thin cracks, which have in many cases been subsequently enlarged by replacement of the wall rock. In the majority of the larger veins small kernels of the host tourmaline granite still remain sufficiently intact for identification.

Collingwood.—The Annan River Company also owns the leases covering portion of the area known as Collingwood Hill, situated near the crest of a ridge on the elevated country connecting Mounts Walker and Tolbert, and lying about half a mile south-west of, and some 600 ft. (vertically) above, Daly's Face: Mineral Leases 176, 177, 227, and 228. No work was in progress at the time of my examination of this property in December, 1914.

The available deposit here, which is generally similar in character, though of lesser workable thickness, to that seen at Daly's Face, was first worked on the surface by W. Sikkema about fifteen years ago. The claim was subsequently sold to various owners, finally passing, nine years ago, into the hands of the present owners, who have carried out practically all the work done.

A race, 6½ miles in length, was constructed by them, included in which length are about 2 miles of fluming, portions of which latter are renewed annually. The total cost of construction of this race worked out at an average of about £1,000 per mile. The water is brought from Pigeon Creek, a right bank tributary of the Annan River; an intake dam is situated on this creek on the northern slope of Mount Finlayson Range, the race running along the southern and western slopes of Mount Walker. Two men are permanently employed as caretakers of this race.

A considerable area of decomposed coarse-grained tourmaline granite, in close proximity to the granite-slate contact, has been sluiced at the main Collingwood Face, on the southern slope of Collingwood Hill, near the left bank of Jones's Creek on M.L. 176.

PLATE 9.—SLUICE-BOX AND PIPE-LINES, COLLINGWOOD FACE, ANNAN RIVER COMPANY.

The deepest portion of the treatable area is apparently located towards the summit of the hill at the western end of these open-cut workings, the ground passing out to surface level at the south-easterly end of the cutting.

Several tourmaline and quartz leaders are seen to traverse the granite at the bottom of the face, striking in directions E30°S, ENE. and E20°S. It is noticeable that a certain amount of rock mashing has taken place along narrow zones bounded by these tourmaline leaders; within this last-mentioned crushed area the granite is seamed with very numerous tiny veins of tourmaline showing a general north-east south-west trend. One such crushed zone was visible in the bedrock in December, at the north-eastern end of the cliff of relatively hard granite blocks occupying approximately the centre of the workings. The granite is usually highly kaolinised within these crushed

areas, and notably so in juxtaposition to the small cross veins referred to above. In the cutting along the main sluice race immediately above the sluice-box fluming over Jones's Creek another band of crushed granite has been exposed in the bed-rock. There are indications here of the effects not only of crushing and shearing but also of faulting to a minor extent. The edges of this crushed zone are strongly marked by the presence of white bands of kaolin with an insignificant quantity of tourmaline. Bands of tourmaline and quartz striking E30°N occur within the crushed area, the general strike of the latter, however, being easterly. An anastomosing system of veinlets of white kaolin striking E30°S radiate out from the walls, notably from the southern edge.

Master joints, disposed meridianally, traverse the main mass of the granite hereabouts. In the large central area of

PLATE 10.—SLUICE-BOXES PREVIOUSLY IN USE AT THE ANNAN RIVER COMPANY'S CLAIM, ROSSVILLE.

rock still remaining on the edge of the open cut, probably owing to its being too little decomposed to allow of efficient treatment by nozzle pressure, narrow seams of fine-grained tourmaline granite have been exposed, dipping W30°S at a low angle. These nearly flat seams are intersected at times by vertical veins of somewhat similar material exhibiting a

north-south trend; in the case of the last-mentioned veins, however, the comparative absence of tourmaline is a noteworthy feature.

Mispickel (arsenical pyrites) occurs sparsely through the granite, as in the case of the Daly's Face, Lode Hill, and Romeo occurrences of stanniferous granite.

Owing to the existence of a considerable quantity of relatively undecomposed bouldery material, the bottom remaining after sluicing here is of a very uneven character. Along the eastern face of the open cut practically no boulders were exposed in December last, but a depth of only 20 ft. of granite has here been sluiced away. At the extreme eastern corner of the cutting, however, a large area of hard granite has been found to exist at a depth of from 15 to 20 ft. from the ground surface.

PLATE 11.—SLUICE-BOXES ACROSS JONES'S CREEK, COLLINGWOOD FACE, ANNAN RIVER COMPANY.

Over the major portion of the area sluiced so far a deposit of "surface" was found, the detritus consisting of some 2 ft. of very stony material containing good tin values and representing in this instance decomposition and enrichment, *in situ*, of the upper surface of the granite.

The maximum thickness of granite, of sufficiently decomposed a character as to permit of efficient sluicing with the

nozzle pressure available, is located in the western corner of the open cut, where a depth of roughly 40 ft. is now showing at the face.

The tailings are disposed of by being allowed to run down a tail-race—timbered in part—to Rossville Creek, some considerable distance from the working face. The forkings consist mainly of pebbles of tourmaline-quartz-felspar rock and hard granite, but these do not represent more than a fraction of the total bulk of stone encountered, the real difficulty experienced being that occasioned by the quantity of large granite boulders to which reference has already been made. The presence of notable quantities of these granite blocks has determined to a degree the method of sluicing that has to be adopted in order that the tin may be won from the surrounding decomposed portions of the stanniferous formation.

Along the southern edge of the cutting a tourmaline leader was sunk on many years ago, and rich tin is stated to have been obtained from it. Numerous irregular patches of bluish-white brittle quartz are to be seen in the granite at the bottom of the cutting hereabouts.

PLATE 12.—NOZZLE FROM COLLINGWOOD RACE, ANNAN RIVER COMPANY.

Several of the leaders occurring at the Collingwood Face were found to carry appreciable tin values. At approximately the centre of the workings one such leader yielded good tin

from the surface to the bottom of the cutting; where first met with this leader was barely an inch in width, but it opened out at irregular short intervals into splashes of quartz containing tinstone.

In the centre of Mineral Lease 228, along Jones's Creek and adjoining the southern edge of the main Collingwood cutting, a fair area of alluvial has been worked in previous years, the stone in the washdirt comprising mainly small slate pebbles. Some 15 ft. of clayey alluvium is exposed along the right bank of the stream.

PLATE 13.—OPEN-CUT, THE COLLINGWOOD FACE, ANNAN RIVER COMPANY.

Showing the face of decomposed stanniferous greisenised granite, and also the large boulders of relatively hard rock.

Several shallow prospecting shafts, some on tourmaline leaders, have been sunk at various times in the past along the crown of the ridge. In one of these shafts, put down by J. Bowditch and party in 1889, a tourmaline "blow" on the surface was sunk on through granite to a depth of 35 ft. A rather flat seam of tin ore was cut in the shaft below the tourmaline; some 6 cwt. of the ore from this seam yielded 3 cwt. of tinstone on being dollied; the width of the seam varied from 3 up to 6 in.

The following return of tin won by the Annan River Com-

pany for the period 1911 to 1914, inclusive, has been furnished by the Warden:—

	Tons	cwt.	qr.	lb.	Value. £	s.	d.
1911	5	14	2	0	595	0	0
1912	33	12	0	8	4,389	19	0
1913	62	18	2	22	8,265	10	0
1914	43	19	2	25	4,148	8	8
Total	146	4	3	27	£17,398	17	8

The Warden's report for the year 1914 contains the following:—"The continuous showery weathery favoured the steady running of all gravity sluicing claims, and as a result there was for the first half of the year very little time lost; from 93,000 cubic yards of material an output of 46 tons 9 cwt. was obtained, 44 tons of which were sold during the period. Sluicing was confined to Daly's Face and at the Collingwood from the middle of January until the end of June."

Whilst the Annan River Company, and particularly the general manager, Mr. E. C. Francis, who has, I understand, invested a large sum of his own private money in this property, are to be congratulated upon the energy and ability they have displayed in rendering possible the sluicing of the immense quantity of stanniferous material undoubtedly occurring here, it must be remembered that the working costs will gradually become greater owing to the increased price of the firewood used at the pumping stations by reason of the already noticeable depletion of easily obtainable supplies. This drawback, which in my opinion will prove of almost paramount importance in the future, might perhaps be eliminated to a great extent by the introduction of some cheaper efficient variety of pump, such as the gas-explosion pump, which would not require the consumption of the large amount of firewood at present being burned.

It should also be borne in mind that the tin contents per cubic yard of the material treated may generally be found to gradually diminish in depth, or, in other words, as the actual contact (usually denuded off) of the slate and the granite is receded from. The granite will also necessarily become less decomposed in depth, whilst the ridges of relatively hard untreatable rock (*e.g.*, that seen in Daly's Face) will in all probability extend to a greater width when followed downwards. The installation of a system of flying-foxes or other similar contrivance would materially assist in the removal from the working faces at a low cost of the accumulations of large boulders which

more or less hamper operations when allowed to remain in the cuttings, as at present, owing to their being insufficiently decomposed to permit of being disintegrated by the water pressure available.

Should it be possible to maintain relatively low working costs in the future, there appears to be no reason whatever why the immense quantity of stanniferous material already definitely proved to exist here should not continue to regularly yield a great tonnage of tin and also afford remunerative employment for a large number of miners and other workmen for many years to come.

Further systematic boring in search for additional similar deposits in juxtaposition to the slate-granite contact, and also to enable the owners to locate the most richly stanniferous portions of the deposit, should be prosecuted with vigour contemporaneously with sluicing operations.

A very considerable saving in the cost of handling the tailings from Daly's and the adjoining faces could have been effected had the proposed dredging of the Rossville Creek, &c., alluvium been carried out in the first instance, in which case the material could have been allowed to run down Rossville Creek and so rendered unnecessary the pumping of the sands to a height of 50 ft. and diverting it into an adjoining gully in order not to cover up the area to be dredged later on.

The amount of logs and boulders that in all probability will be met with during dredging operations here will prove a source of inconvenience and delay; bucket dredging has undoubtedly proved to be by far the cheapest form of handling alluvium yet tried in Australia under *ideal* conditions, but, speaking generally, such do not, in my opinion, exist on the extensive dredgable area belonging to this company.

Collingwood Tin Lode.—As this lode was examined and sampled when accessible by my colleague, Mr. L. C. Ball, prior to my visit to this district, that gentleman has kindly offered to publish his notes on the lode for general information. The lode in question is now included within the area held by the Annan River Company.

Native Youth Claim, situated on the left bank of Wallaby Creek immediately below the junction of Jones's Creek and close to the village of Rossville. The average depth of the ground is about 15 ft., the washdirt constituting the lower 2 ft., whilst the overburden consists of 6 ft. of yellow sandy clay resting on

about 7 ft. of stiff blue clay. The bottom is composed of moderately even soft slate. The washdirt is composed essentially of slate pebbles of medium size, as also a lesser amount of tourmalinised granite. A hard slate bar is exposed across the bed of Wallaby Creek just above the working face. Work is being carried on in an upstream direction towards the junction of Jones's Creek. Water for sluicing is obtained from Byers's Gully, and is conveyed by a pipe column of small diameter on to the face from a small supply dam on the adjoining ridge above the main road from Rossville to the Annan River Company's workings. This claim is worked by Yeatman.

Plate 14.—Native Youth Claim, Wallaby Creek, Rossville.

Carnival Claim.—Working along the southern side of the bed of Wallaby Creek at a point about half a mile downstream from Rossville public-house, at the top end of White's Beach. This claim has been worked intermittently during dry weather by Geo. Yeatman for about three years, during which period some 2½ tons of tinstone have been obtained. The tinstone is mostly black in colour, but there is also present a little white, ruby, and amber tin, all being of fine grain: assays about 72 per cent. The washdirt is barrowed to a sluice box. The owner informed me that the yield of 4 lb. of tinstone per cubic yard obtained by him was not proving payable at the present price of tin, combined with the slow method of working which the

nature of the deposit compels him to pursue. Water for washing is obtained from Nolan's Gully by a race a mile in length, and then conveyed across Wallaby Creek by a pipe line of 7 in. and 5 in. diameter; pressure available, 25 ft. There is usually an abundance of water for sluicing purposes, but as mining is practically limited to the treatment of flood-borne material, operations are usually possible only during the dry seasons, when Wallaby Creek is low.

A large quantity of ilmenite occurs here with the tin. Occasional small pieces of bluish cyanite (silicate of alumina) are met with during streaming operations. The bottom (granite) is extremely uneven and covered with huge granite boulders. The overburden is ordinary loose creek sand. Small patches of rich ground are occasionally met with, having been either missed by the early miners or left owing to being at that time unworkable. The bottom rises sharply under the left bank. A little washdirt occurs on the surface a short distance up the ridge towards the Rossville road.

Jones's Claim, on the lower portion of Jones's Creek, 8 chains upstream from its junction with Wallaby Creek, now being worked in the bed and along the left bank of the creek by Charles Ross and Hy. Bowditch. The overburden is of shallow depth, and rests upon 2 ft. of washdirt. Heavy stones have to be contended with. A moderate amount of stream tin is won as "flood tin" brought down by the stream during heavy rains. A limited amount of slatey washdirt is being treated along the left bank of the creek, but the rather sharply rising very uneven bottom indicates that this deposit may not be found to extend far from the stream channel proper. Work is possible on this claim only in the dry weather, as at other times the creek assumes larger proportions, and the ground is covered with water. This claim has been so worked by various holders for many years in succession. The tin is richest right on the bottom usually. The alluvial here has been worked in the past right across to the Trixie Claim (described below). A strong bar of hard slate crosses the creek just above this claim, the hardness of the rock forming the bar having been produced by the intrusion into the slate country of an aplitic granite dyke 3 ft. in width.

Trixie Claim—owned and worked by Messrs. E. W. Parsons and J. Pesanti: situated along the right bank of Jones's Creek near the junction of Darby's Creek and close to Wallaby Creek. Work has been carried on here by the present owners for the past couple of years. The average depth of alluvial is about

20 ft., comprising 12 ft. of a sandy clay overburden on top of 8 ft. of gravelly washdirt mainly composed of slate. The bottom is very uneven and of slate; it is often of a puggy character. Water for sluicing is obtained from Jones's Creek at a point some 500 yards upstream from the workings; the quantity available varies from 1 to 12 sluice heads, according to the seasons. This area is being worked with an elevator and a nozzle with a 1¼-in. bit; 60 ft. of pressure is obtained. The tinstone is mainly fine-grained and partly waterworn; it is of generally high grade, assaying from 73 to 75 per cent. in bulk parcels. An area of approximately 400 ft. by 300 ft. has been worked. The present owners had won some 8 or 9 tons up to November, 1914, but a considerable area of payable ground still remains to be worked hereabouts. A total of three men have been permanently employed on this claim up to the present. With regard to the distribution of the tin values, it would appear from the results obtained hitherto that the best returns are secured from a seam in the washdirt lying about 2 ft. above the bottom; no tin has so far been found actually in the bedrock here. A limited quantity of black sand occurs with the tin, but not in sufficient amount to cause trouble. Neither gold nor gemstones have been recorded as occurring here. At the time of my visit at the latter part of 1914 the owners were engaged in constructing a supply dam on the side of the ridge a short distance above the working face.

Eclipse Claim.—Wm. Yeatman; situated near the upper portion of Byers's Creek, a small left bank tributary of Wallaby Creek a short distance south of Rossville. The major part of the work carried out here has been on a low ridge running parallel to and above the left bank of Byers's Creek. Operations were commenced about fourteen years ago. In the westerly workings (upstream) an area of approximately an eighth of an acre has been sluiced to a shallow depth, the bottom rock being soft red granite containing occasional small quartz leaders. Judging from its location and the character of the stone met with in the washdirt a fair amount at least of the tin won has come originally from the denudation of the more elevated country immediately adjoining the ridge on the south-western side—viz., Mount Tolbert and spurs therefrom. There is a very even grade to the slope of the bottom at the workings, indicating an absence of any appreciable amount of erosion of that rock. The stone through the alluvium is quite angular, and is in all probability merely detrital material from the adjoining higher ridges as above stated; it consists of medium and fine-grained granite and tourmaline boulders with occasional angular fragments of slate.

The frequently aplitic character of the granite met with hereabouts is due to the comparative proximity of the latter rock to the slate contact seen less than half a mile upstream, and the tin in the detrital material worked here doubtless owes its origin to the denudation of the mineralised zone along that contact.

Water for sluicing purposes is obtained from Byers's Creek, but the supply is precarious and usually efficient for only eight or nine months of the year. The stanniferous deposit occurring here may be classed practically as "surface." Much of the quartz present in the stone is of the rose variety. Several aboriginal implements have been found through the material treated on this property.

At the time of my visit in November, 1914, work was being carried on at the easterly workings a short distance east of the westerly workings described in the aforegoing, and also in and along the main stream channel of Byers's Creek. The average depth of the alluvium worked here may be set down as about 10 ft., but occasionally depths of as great as 20 ft. have been met with. The bottom consists in the main of kaolinised granite, much of which latter is extremely fine-grained. From the appearance of the workings, the tin occurs in approximately parallel runs of narrow width, which are probably coincident with former variations of the position of the stream bed. The stone included in the washdirt here is relatively more abundant and waterworn than in the case of the westerly area sluiced. The tinstone is fine-grained, although very occasional nuggets up to 3 lb. in weight have been obtained. There still remains a considerable area of ground to be treated on this claim, but the average returns up to the present can only be described as fair. A total tonnage of 14 tons of tinstone is stated to have been won from both workings in the fourteen years during which Yeatman has been engaged here, or an average of 1 ton per year. The granite bedrock is studded with abundant blebs of tourmaline, but does not appear to have up to the present yielded any tinstone.

A small amount of work was done some years ago between Byers's Creek and its small right bank tributary, and also along the latter; this gully joins Byers's Creek just below Yeatman's workings and close to his camp.

Erin-go-Bragh Claim—owned by W. W. Casement; situated on a small right-hand branch of Nolan's Gully about 5 chains

above the junction with the latter, and about 1,200 yards north of Rossville post office. Nolan's Gully is an important right-bank tributary of Wallaby Creek, which it enters at the village of Rossville. The owner is working along the left bank of the gully, operations having been commenced by him in the early part of 1914. The average depth of the alluvial is about 6 ft., this material resting upon a very uneven soft granite bottom. The washdirt is composed of from 1 to 2 ft. of clayey wash containing very little stone, the latter comprising mainly small granite fragments. The overburden along the bank closely resembles granite at first sight owing in part to its being highly cemented. Water for sluicing is obtained from Nolan's Gully by a race a quarter of a mile in length, there being usually about an eight months' efficient water supply available. This ground had been previously worked to a limited extent by P. Nolan and also subsequently by Holmes. A strongly marked quartz leader and several veinlets of tourmaline traverse the bedrock in a north-west direction. Near this leader a band of yellow decomposed tourmaline granite carried tin for at least 2 ft. in depth.

This area is very patchy as regards the occurrence of the tin values. An area of roughly 3 chains in length by 1 chain in width has been worked. The tin is medium grained, and consists of both partly waterworn and angular grains assaying up to 75 per cent.; colour black. In the central portion of the area a considerable quantity of slate occurs through the washdirt, overlain by loose granite sand; very little iron sand is found here, but lower down this material amounts to as much as 5 per cent. of the concentrates at times. The presence of this slate in the washdirt here suggests the possibility of another tin lead. The quantity of granite boulders in the upstream portion of the workings militates against cheap working. The average yield at the face is stated to be about half an ounce to the dish.

Ross and Kastner's Claim.—A limited amount of work at the junction of granite and slate has recently been carried out by this party in the alluvium along the left bank of Jones's Creek immediately below the Collingwood boarding-house, with, it is understood, only fair results. A line of pipes operating a nozzle was installed, the water being obtained from Jones's Creek a few chains upstream, but the supply was inadequate except during the wet season. The depth of the ground is from 10 to 15 ft., the bottom 4 ft. of washdirt carrying the principal values Several boulders of tourmaline carrying tinstone occur through the washdirt.

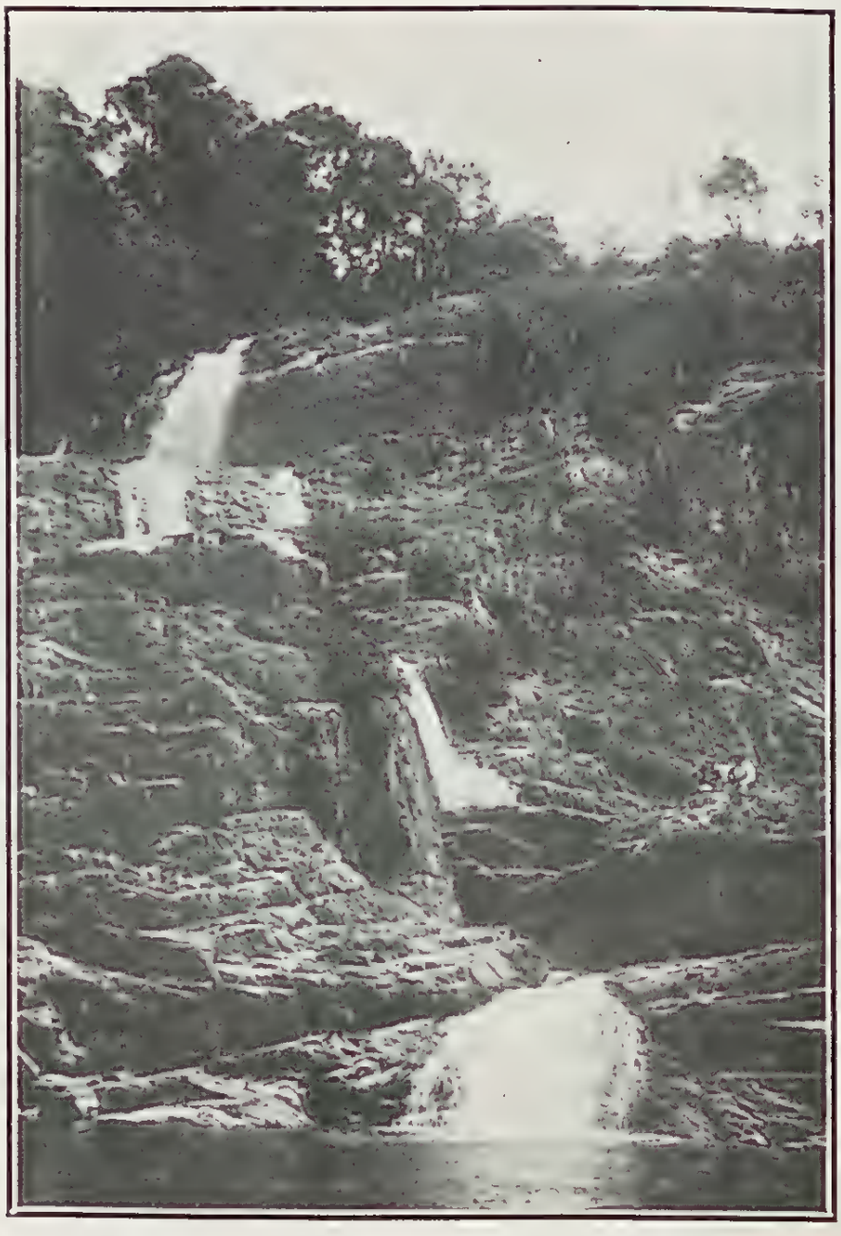
Kerr's Claim.—Also known as the *Winifred United;* situated on the left bank of Jones's Creek,* between Jones's Creek and Mulligan's Gully. This claim was worked in the early days (at least as far back as 1886), when the alluvial proved to be very rich along both of the stream channels named. The deepest portion of the alluvial was up the centre of the dividing ridge between the two waterways. The property is now being worked by David Kerr. Water for sluicing is obtained from Jones's Creek by a race ¾ mile in length, but in the drier portions of the year the supply available is insufficient for both nozzle and elevator. Approximately, 250 ft. of head pressure for sluicing exists here. About 15 ft. in thickness of washdirt overlies the granite on the hillside. The alluvium here consists essentially of sandy clay.

PLATE 15.—D. KERR'S CLAIM, JONES'S CREEK, ROSSVILLE.

On the downstream portion of the claim, where work was in progress at the time of my visit at the latter end of 1914, there is about 20 ft. of clayey sand resting upon 8 ft. of gravelly granite, quartz, tourmalinised granite, and slate wash resting upon a soft, very uneven granite bottom. Sluicing is carried out by means of a nozzle (1½ in.) and

* Jones's Creek is named after the first prospector, who worked the alluvium along the stream (near Collingwood).

elevator. The tinstone is black and waterworn; very little black sand accompanies the tin, whilst gemstones have not yet been recorded here. A piece of corundum about 1 lb. in weight was found on one occasion. The granite bottom is traversed by numerous quartz leaders carrying a little tinstone and much tourmaline; strike E20°S. It is the intention of the owner to work towards Mulligan's Gully next wet season. A very considerable area of alluvium still remains to be worked on this claim along Jones's Creek, and also at the junction of Mulligan's Gully. Last season a total of 7 tons 5 cwt. of tinstone was sold, obtained from an area 30 yards by 50 yards by 21 ft. in depth. The ground is very uneven as regards the distribution of tin



[*Photo., R. Graff.*

PLATE 16.—HOME RULE FALLS, SLATEY CREEK.

The intake of the New Queensland Tin Sluicing Company's (Home Rule) pipe column is at the top of these falls.

values. During the wet season there are usually six men employed here, in addition to the owner. Several years of profitable work are undoubtedly ahead of this property if mining operations are continued in the same way as at present.

New Queensland Tin Sluicing Company, No Liability.—(Formerly the Queensland Tin Sluicing Company, N.L., of which latter David Lindsay was general manager.) Manager of present company, Alexander Hedley. The property controlled by this company consists of Dredging Claim 840 and Mineral Lease 197, &c., situated at Home Rule, about 1½ miles due east of Rossville, near Wallaby Creek, and a short distance west of Slatey Creek.

Operations commenced about eight years ago. At the time of my visit sluicing was being carried on on Dredging Claim 840; the eastern portion of Mineral Lease 197 (immediately in front of the manager's residence) has been already practically worked out.

Water for sluicing is obtained from Slatey Creek at a point just above the top of Home Rule Falls, which are distant three-quarters of a mile in a north-north-east direction from the present working face. An average of eight ground sluice-heads of water is stated by Mr. Hedley to be available for nine months in the year, the remaining three months the quantity being from eight heads down to a minimum of three.

The aneroid gave the following average readings:—Foot of Home Rule Falls, 650 ft. (Rossville is 500 ft.) above sea level, top of falls 790 ft., working face 640 ft., ground level at the manager's residence about 210 ft. below the column intake; from these figures the height of the falls would be 140 ft., whilst the head pressure from the column intake to the working face would be about 150 ft. at the nozzle. The slate formation over which the water tumbles at the falls is extremely hard, and presents many indications of having been altered by subsequent silification directly resulting from the intrusion of the granite, which latter rock is exposed along a north-south line at the surface a short distance westerly. A large quartz blow occurs near the south-eastern corner of Mineral Lease 232. The falls are very picturesque, occurring rather as very steep cascades than as one vertical fall. Very deep holes have, as usual, been produced at the foot of the falls, and also at a point half-way up the cliff face, by the fall of the water. The accompanying photograph (plate 16) gives a view of the falls, and illustrates their cascade nature, the jointed character of the

slates, and also the production of a deep pool at the bottom of the falls. Numbers of eels are found in these deep pools both here and elsewhere in the district.

The sluicing water is conducted from the top of the falls along a 20-in. diameter pipe column, the pipes being of the spirally riveted variety and constructed of 12-gauge steel (average); from 20 in. the pipe column is reduced in diameter successively to 18, 16, and 14 in., with 12-in. extension pipes; in all there are 1½ miles of pipes in use on the property. A "giant" nozzle with bits from 4 in. downwards is employed; when on the lower workings the nozzle on the elevator was lifting the material 36 ft.

A 10-horse power generator, run off a turbine by water pressure, is used for lighting purposes, running four arc lights. A saw bench, driven by a pelton wheel, was installed for the purpose of cutting the timber required in the races, &c. Cedar was found to be the only readily obtainable timber which proved satisfactory by reason of its lengthy life in water.

The depth of ground at the present (November, 1914) working face is about 40 ft., the depth gradually diminishing to nil on both sides. Work is being carried on up the centre of a spur from Mount Hedley. The bottom rock consists of slate, which latter is here largely decomposed to a clay; the grade of fall to the bottom is fairly even. Tin occurs through the alluvial right from the surface to the bottom, but the best values are located in the lowermost portion of the material.

Several very coarse slugs of tinstone have from time to time been unearthed, pieces up to as much as 85 lb. in weight having been recorded. The tinstone now being obtained is mainly black tin, with much angular "specimen" tin, and also some crystallised tin of frequently reddish to amber colour. A noteworthy occurrence here is also the occasional presence of nearly white tinstone. In bulk parcels the tinstone obtained from this claim has assayed from 70 to 73 per cent. A small amount of black sand accompanies the tin.

The present paddock of ground has in places averaged 1 lb. of tinstone per cubic yard, but this figure has not been maintained, the results indicating that the distribution of the tin values is patchy. Several quartz leaders occur through the slate bottom in the lower workings on this property. These leaders were frequently found to carry coarsely crystallised tinstone.

No gemstones have been recorded, and gold is not usually noticed when streaming, though a nugget of 1½ dwt. is stated to have been obtained on one occasion.

The capacity of the sluicing plant in use here is estimated by the manager to be at present at least 50 cubic yards per hour; it is intended in the near future to install a 14-in. column by a more direct route, in order to treat the material on a second spur situated further to the west of the present face, when a much greater capacity will be available.

The best ground at the present working place is making up the centre of the face. Many of the granite boulders occurring in the overburden have been quite decomposed *in situ*, indicating a former stream channel of greater geological antiquity than that of the Recent alluvials along present stream channels.

It is of interest to record a distinct change in the colour of the tinstone with alterations in the various sedimentary rocks constituting the underlying bedrocks, the redder the decomposed slate the redder the colour of the tinstone. This colouration of the tinstone is doubtless referable to the deposition thereon by water of iron oxide leached from the underlying sedimentary formations. It is usually found necessary to sluice off a small depth of the decomposed bottom in order to obtain the tinstone which has worked its way downwards through the washdirt.

Along the right bank of Home Rule Gully an area of approximately 40 chains in length by 5 chains in width has been sluiced out, mainly in the stream bed and in terraces along the right bank. The terrace deposits run out shallow, but average 15 ft. in depth; they contain both fine and coarse grained tinstone. In the main portion of these lower workings two distinct runs of tin were traced and found to cross each other. Much of the creek bed here averaged 21 ft. in depth for an average yield of 1 lb. of tinstone per cubic yard.

The Warden's Annual Report for 1914 states that 7½ tons of tin oxide were recovered from 40,000 cubic yards of material and disposed of for £717 10s. 6d.; a further 1¾ tons were recovered later and shipped for sale. The average number of men employed throughout the year was seven, but the company intend to extend the stationary branch of the main column further west and employ more men and work two nozzles as constantly as possible.

For the period 1911 to 1914 inclusive the following returns have been recorded from Home Rule:—

	Tons	cwt.	qr.	lb.	Value. £	s.	d.
1911	9	6	0	0	1,138	0	0
1912	9	2	0	0	1,241	10	0
1913	27	1	2	10	3,427	0	0
1914	7	10	0	20	717	10	6
Total	52	19	3	2	£6,524	0	6

A prospecting shaft 30 ft. deep was sunk about four years ago by Higgins in decomposed slate close to the granite contact at a point a short distance south of the southern boundary of M.L. 232. Numerous small quartz leaders carrying coarse tin were cut, but the total quantity of tin obtained was insignificant.

At the "Landing," about 10 chains easterly of the boundary of D.C. 840, a quartz leader running N.W. S.E. in granite was worked in hard aplitic granite, which latter runs as a narrow dyke for at least half a mile in a south-easterly direction; the strike of the quartz vein is north and south. A few bags of tin were obtained from this occurrence.

Three photographic views showing respectively the lower end, central position, and upper ground worked by this company were published in the "Queensland Government Mining Journal" for January, 1915.

Southern Cross Lode—on Mineral Lease 232 (A. J. Madden); near the right bank of Slatey Creek, the eastern boundary of the lease abutting on the Home Rule Falls. A tunnel has been put in northerly into the eastern side of a steep hill for 40 ft., the country rock being hard normal granite close to the slate contact. The position of this tunnel is close to the southern boundary of the lease, towards the south-west corner. A small amount of tin was obtained here from a quartzose leader. No work has been done here for many years, but when working this lode was known as the Southern Cross. The tin-bearing quartz is bluish, and carries some tourmaline; it appears to follow a master joint in the granite.

Slate occupies the bed of Slatey Creek for a considerable distance upstream beyond the Home Rule Falls; this formation has everywhere in this locality been rendered intensely hard by the intrusion of the granite, which latter rock outcrops high up on the eastern side of Mount Hedley. The granite is here of the fine-grained acid type, containing abundant blebs of tourmaline and several tourmaline "blows," particularly along the actual

contact zone. Frequent shallow trenches have been put in along the mountain side in dense scrub country overlooking Slatey Creek, in search of tin lodes, which are thought to have shed the tin found on the surface all along this area. The ground, if sufficiently stanniferous, is suited to work by parties of two or three men, but a certain amount of pumping would be necessary except perhaps during the wettest portion of the year, when contour drains would suffice to supply the requisite sluicing water. I have been shown three large slugs of tinstone from this area. Tin has been worked along the bed and on the right bank of Slatey Creek by Jackson and others during the past three years, the tinstone being coarse-grained.

Granite comes down to the right bank of the creek at a point about a quarter of a mile below the Bunks Falls, and crosses over Bunks Creek some distance above the junction of the latter with Slatey Creek. Tin has been worked along the Bunks Creek, more particularly near its junction with Slatey Creek, the washdirt comprising mainly boulders of tourmalinised granite resting upon a bottom composed of vertically dipping slates.

Bunks Falls are situated on Slatey Creek at a point about three-quarters of a mile north of the Home Rule Falls and a few chains upstream from the junction of Bunks Creek. The rock is hard slate and quartzite, and the presence of master joints and cleavage lines has enabled the stream to entrench itself in a narrow race-like channel through the hard rock mass. A characteristic feature of the stream bed hereabouts is the number of deep holes at the foot of the cascades along the course of the creek.

Above Bunks Creek a very narrow gap of rock (granite) constitutes the watershed between the water flowing into Slatey Creek from that constituting the upper waters of Nolan's Gully, which latter empties into Wallaby Creek at the village of Rossville.

Homeward Bound Claim.—Owned by Frank Williams; situated in scrub country along Angus Creek immediately downstream below the track from Rossville to Ayton, and close to the slate-granite contact. The bottom here is of soft granite and is overlain by 4 ft. of sandy loam resting on a further 4 ft. of partly waterworn washdirt consisting largely of slate stones with some granite and numerous boulders of granite averaging 1 ft. in diameter. An area of approximately 80 yards by 50 yards had been sluiced up to the time of my visit in November,

1914, but no work was then actually in progress. The bottom is very uneven. A drawback to the successful working of this claim is the large quantity of stone to be handled.

[*Photo., Spcarritt.*

PLATE 17.—HOMEWARD BOUND (F. WILLIAMS'S) SLUICING CLAIM.
In scrub country, near the Rossville-Bloomfield track.

Lorna Doone Claim.—Owned by Messrs. A. H. and F. J. Francis; situated on M.L. 233, on the edge of the Bloomfield Scrub, adjoining the main track from Rossville to Ayton, and distant 3¼ miles by track from Rossville village. Operations were commenced here about three years ago, and work was still in progress at the time of my examination of this portion of the district.

Water is obtained by a race from The Falls Creek, which heads on Mount Finlayson Range, and is conveyed out on to the lower spur of that range, thence by fluming, &c., to a dam in Siphon Creek,* thence the combined waters are conveyed by race a distance of 300 yards to the workings. There is usually

*Siphon Creek is a left bank tributary of the central branch of a creek rising on Mount Hartley on the ridge separating Mount Hartley from Mount Finlayson, the combined waters forming a left bank tributary of Mount Hartley Creek.

sufficient water to operate a 1¾-in. nozzle at a pressure of 120 ft. for about nine months in the year, but during the wet season, during portion of this period, a much greater supply is available. An additional water supply can also be obtained from Three Jims Creek, which latter is already connected to the claim by a quarter of a mile of fluming and pipes.

An area roughly ¾ acre in extent has been sluiced out up to the present, most of the workings being in close proximity to the slate-granite contact. Tin occurs through the bottom rock in cases where granite forms the bedrock.

On the lower (eastern) side of the area treated the average depth to bedrock is about 9 ft., the lower 7 ft. of which is washdirt. Traces only of tin are found through the overburden; the best values found hitherto have been met with at a point 1 ft. above the bedrock. Along the higher (western) side the average depth is about 20 ft., whilst towards the central portion of the working face the washdirt indicates a further deepening. About the same thickness of washdirt occurs on this side as on the eastern side, but the values are on the whole lower. A little tin occurs right through the overburden and fair values in the washdirt, but at times the mineral is present in very small quantity only. The bottom presents a comparatively even surface with a gentle dip in an easterly direction. The tailings pass through a deep tail race cut down to the level of the washdirt, which here probably rests upon a slate bottom.

By far the greater portion of the area sluiced up to the time of my visit in November, 1914, rested upon a slate bottom, but fine-grained acid granite is now making its appearance along the western edge, and more particularly towards the south-west corner of the worked area. The granite is here largely kaolinised, and carries fine brown tinstone. The overburden consists mainly of ferruginous clayey material on the western portion and yellow sandy loam on the eastern portion. Notably along the western side the alluvium has become somewhat cemented in its upper portion, and occasionally necessitates the use of explosives, dynamite being considered the most suitable agent under the particular conditions obtaining in this locality. A very small quantity only of stones occurs through the washdirt.

Occasional "colours" of gold have been seen, but no gemstones have been observed. No grains of tinstone larger than pea size appear to have been found here up to the present. A very little black sand occurs at times. The assay value of the

tinstone has been very high, ranging from 75·1 to 75·8 per cent., the mineral being partly waterworn red, white, and black tin easy to clean. The owners inform me that they experience no difficulty in obtaining a high grade concentrate by the use of a wide (say 2 ft.) streaming box with a good supply of water and set with a "fall" of 5 in. in 12 ft.; they use a flat streaming shovel. The thick timber and scrub on the side of the workings adjoining the eastern face has been lately cut down preparatory to a continuance of sluicing next season in that direction towards Siphon Creek, but it is also intended to work the deeper ground into the hillside.

A considerable area of ground still remains to be worked, the owners estimating that they have about fifteen years' work ahead of them at the present rate of working. It is intended to take a new tail race through about the centre of the eastern face; from this point to the creek is about 150 yards. Some 16½ tons of tinstone are stated by Messrs. Francis Brothers to have been won by them, in addition to which a fair amount of "surfacing" was carried out about fifteen years ago by previous holders of the ground, also along Siphon Creek and Slatey Gully in the immediate vicinity. A little tin is obtainable from all over the adjoining rising ground. The total number of men permanently employed on this property averages 3½ throughout the year. No "leaders" whatever have been up to the present seen traversing the slate bottom. Several small boulders of quartz with much plumose mica have been found among the wash stones, which have in all probability arisen from the disintegration of the fine-grained acid granite along the contact with the slate country. In Slatey Gully coarse black tinstone is obtainable from the granite itself. In the dense scrub country of the Bloomfield Scrub above the track to Ayton, at the south-eastern corner of this lease (M.L. 233), good tin is obtainable from the granite soil between the granite boulders in the small right bank gully which joins Siphon Creek a few chains downstream. In another adjoining short gully forming a right bank tributary of the creek, near the lease boundary, a limited amount of work has been carried out on a highly decomposed granite carrying patches of rich tin. This area could be readily sluiced with water diverted from the head race for the main claim, which passes along the ridge above it. Payable tin values are stated to exist through the overburden here. A small patch of slate, 2 ft. in thickness, is exposed below the surface alluvium, indicating that the deposit is a contact one. The tinstone is black in colour and medium to coarse in grain. A deposit of alluvium up to 6 ft. in thickness occurs over the surface here.

Good tin values are stated to have been found in the kaolinised veins traversing the granite bedrock. It is intended in the future to place a box drain here and work this gully bed and the banks up the side of the ridge. It would be necessary to install an elevator to work the alluvial at the junction of this gully with Siphon Creek. Numerous granite quartz boulders exist through the washdirt in Siphon Creek; this material has been derived from the denudation of outcrops of that rock on the Bald Pocket, 1½ miles upstream. For a distance of some 300 ft. above the level of the main claim fine tin is obtainable from the bottom of the head race after wet weather, indicating the probable existence of values in that direction.

The Warden reports that for the year ending 31st December, 1914, this claim yielded 5½ tons of tinstone from 9,700 cubic yards of alluvial treated; estimated value of tinstone, £550.

[*Photo., Spearritt.*

PLATE 18.—LORNA DOONE CLAIM (FRANCIS BROTHERS).

At the entrance to the Bloomfield Scrub, near the Rossville-Bloomfield track.

Three Jims Claim.—Also owned by the Messrs. Francis Bros.; this sluicing claim adjoins the Lorna Doone lease on the western boundary. The ground has been partly worked out, having been worked by various owners for a considerable period prior to its being taken up by the present holders. Operations here have been mainly of a developmental nature, the work carried out consisting of the bringing in of a tail race and

laying on the water to sluice an area on the right bank. The bottom is here of soft granite. The tail race mentioned had to be blasted out of very hard granite close above the present Rossville-Ayton track, and occupied three men for thirteen weeks in the construction; it is about 2 chains in length and 8 ft. in depth. This claim was originally opened by Messrs. James Dick senr. and junr.; it afterwards passed into the hands of Rt. Haeslop, by whom it was disposed of to the present holders. There is usually a sufficiency of water available for sluicing.

The lower portion of the area is practically unworkable at present owing to the extremely soft nature of the granite bedrock. The tinstone averages 73 per cent. metallic tin, and is of the medium-grained black variety. Three Jims Creek runs into the same creek as Siphon Creek about 1½ miles below the latter and roughly a mile below the Three Jims claim. In the face now exposed by Francis Bros. there are numerous large boulders of granite with slate and granite washdirt between them, the whole resting upon a very soft granite bottom traversed by quartz leaders. Haeslop originally had a sluicing plant in operation there, consisting of 900 ft. of 7-in. piping operating a nozzle with a 1½-in. bit, and yielding 90 ft. of pressure. The relative flatness of the ground proved a great hindrance, as the tailings could not be got rid of, an elevator being in reality a necessity if this claim is to be made payable. Prior to Dick's time a prospector named Thos. Malcolm obtained several tons of tin from a left (west) bank "blind" gully tributary.

The main creek falls from tin-bearing country from the foothills of Mount Finlayson Range over a slanting face of granite located about 100 yards above the present workings, and payable values are reported to occur upstream as far as the foot of this granite rock.

Redivivus Claim.—Owned and worked by Messrs. Thomas Kinnerk and Alex. Hinsley; situated in the Bloomfield Scrub on Whitehead's Gully, which latter rises on the eastern side of Bald Pocket and joins a left-hand branch of Wallaby Creek a short distance downstream from the working face near the track through the scrub from Rossville to Ayton. There is usually an abundance of water for sluicing purposes available for from nine to ten months in the year. Work was carried on at this area as far back as 1885 with, it is stated, very good returns. The ground was taken up by the present owners about three years ago, since which time between 3 and 4 tons of tinstone have been won. The tinstone is mostly very fine-grained and black in colour, assaying up to 76 per cent. at times. Odd "colours" of

gold are occasionally found. The average depth of the alluvial is about 15 ft., but depths to as great as 25 ft. have been attained, particularly along the southern side of the workings.

At least 10 chains in width of alluvial has been proved to exist here, but a little tin is also obtainable from the surface soil for a considerable distance surrounding the workings. A moderate amount of stone occurs through the washdirt, consisting almost exclusively of small semi-waterworn quartz and highly acid granite fragments and accompanied frequently by clear quartz crystals up to 4 in. in length. An ordinary fire hydrant with a 1½-in. nozzle was in use when the claim was visited by me; a pressure of 35 ft. was then available, but 70 ft. of pressure is obtained during the wet season. The owners were engaged in putting a deep tail race through slate and granite to replace the old tail race shot through a hard granite bar by Whitehead and party twenty years previously. The slates, which are here remarkably well cleaved, strike north-west south-east with a slight north-easterly inclination. The alluvium consists of granite sand containing a little tin.

[*Photo., Spcarritt.*

PLATE 19.—REDIVIVUS CLAIM (HINSLEY AND KINNERK'S), IN THE BLOOMFIELD SCRUB.

Showing a typical face of alluvium along the edge of the dense vegetation.

Numerous quartz veins here traverse the granite but no tin has so far been noticed in them. In the workings the granite bedrock is frequently so soft in character as to necessitate the

use of timber for the sides and bottom of the sluice races, kauri pine and cedar having been found to give the best results for this purpose. The granite is mostly a fine-grained aplite with blebs of tourmaline; rose quartz is common in the washdirt. In what is known as the Big Face, situated on the right bank of Whitehead's Gully, about 2 chains farther away from the creek, a thickness of 20 ft. of sandy clay overburden rests upon 6 ft. of stony wash comprising angular boulders of quartz, granite, greisen, &c. Seams of blue puggy clay are exposed here in the face. The bottom is of soft granite with most of the tin lying directly on top of it; the alluvial here appears to be increasing in depth going into the hill. Seams of tourmaline sand several inches in thickness occur in the wash, but very little iron sand has been met with.

[*Photo., Spearritt.*

PLATE 20.—REDIVIVUS CLAIM.
Showing the method of sluicing with a hydrant.

Consolation Claim.—Worked by Messrs. Wm. Horder and Haeslop; situated along a spur on the right bank of Moses Creek, in the Bloomfield Scrub, to the north of the Rossville-Ayton track. Operations have only very recently been commenced on this area. The average depth of alluvial is 5 ft., the material resting upon a soft slate bottom of uneven surface. Most of the tin obtained so far has been found to occur in puggy clay quite close to bedrock. The overburden consists almost entirely of red slate detritus; practically no stone occurs in the wash-dirt. Water for sluicing is obtained from Moses Creek, which

latter heads below Mount Hartley and joins a left branch of Wallaby Creek a quarter of a mile downstream below the Bloomfield track crossing over that branch; an abundance of water is available during the wet season. Angular coarse black tin of high grade is found here. It is intended by the owners to sluice the surface off the spur on which their claim is located; a considerable area of ground is available for this purpose providing the material carries tin values payable under the system of work in vogue. Huge granite boulders cover the surface in part hereabouts, but the true bottom rock appears to be slate. The bed and sides of Moses Creek are remarkably ironstained.

Shipton's Flat and Tabletop.

This portion of the field is situated in the south-western section of the upper Annan River drainage system and lies about 8 miles (by track) south-south-westerly of Rossville and a short distance easterly from the Cooktown to Grasstree road. There is a public school, as also a postal receiving office, at Shipton's Flat.

Parrot Creek, on which stream and small tributaries thereof the mining is at present carried on, joins the Annan River at the road crossing on the Grasstree road, the junction of these two waters being known as the Little Forks. (See Map No. 2.) Parrot Creek is better known locally under the name of *Pigeon Creek*, but it will be hereinafter referred to always under its official name of *Parrot Creek*. A band of hard quartz-sericite-schist crosses the road about three-quarters of a mile on the Cooktown side of the Little Forks at the rough ridge locally designated Rogan's Folly. Through portion of the Big Scrub and along the road, notably around the public school, occurs an extensive outcrop of basalt, whilst several porphyry dykes intrude the slates—*e.g.*, on portion 38v, and also between Shipton's and the Little Forks. The upper right-hand branch of Parrot Creek is known locally as Rossville Creek, and flows partly through dense scrub.

By far the most important claim is Shipton's, on M.L. 240, the only other mineral lease in force being Spargo's (M.L. 234) at Tabletop.

The Warden's report for the five-year period, 1910-1914, gives the yield from this portion of the field as follows:—

	Tons	cwt.	qr.	lb.		£	s.	d.
1910	13	2	3	21	worth	1,279	6	5
1911	10	13	0	3	„	1,244	11	0
1912	15	16	3	7	„	2,168	8	0
1913	17	16	3	7	„	2,393	11	10
1914	11	18	2	17	„	1,167	2	0
Total ..	69	8	0	27	„	£8,252	19	3

Shipton's Claim.—Mineral lease 240, standing in the name of Messrs. Arthur C. and H. Percy Shipton; area, 20 acres. This claim is situated at Shipton's Flat, the area comprised within

[*Photo., W. Horsfield.*

PLATE 21.—TYPICAL "OCTOPUS" FIG-TREE OF GIANT PROPORTIONS.
Growing in scrub country, Shipton's Flat District.

the lease being located mainly on the right bank of Parrot Creek. A portion of this property was sluiced about four years ago by Albert Lee. Towards the southern corner of the lease

PLATE 22A.

[*Photos., W. Sykes.*

PLATE 22B.

W. SYKES'S CLAIM (NOT NOW WORKING), PARROT CREEK.
Showing hand-methods of winning tinstone; (A) "Stripping," and (B) "Streaming."

the average depth of the alluvial is 20 ft., but depths of up to 25 ft. have been reached. In the case of the deep ground the tin is practically confined to the washdirt, the thickness of the latter being about 2 ft.

In the shallower (5 ft. deep) ground good tin appears to have been obtained from the surface downwards. Only a small quantity of stone was met with in the washdirt. The tinstone was of high grade consisting largely of grey and white tin. No gold or gemstones were found during cleaning up. The present owners won some 4 tons of tin from these particular workings, but a much greater quantity is reputed to have been obtained previously from here by Lee. Upwards of an acre has been sluiced, but only a fraction of this has been actually worked to the bottom.

Towards the southern peg of the lease the ground becomes cemented, requiring the use of explosives right from the surface, dynamite being employed for the purpose. The overburden consists mainly of reddish clay, the washdirt being composed of small slate fragments and carrying its tin values evenly distributed through itself. No tin-bearing leaders have yet been seen traversing the bottom. The tinstone is very waterworn and the amount of black (iron) sand which accompanies it is insignificant.

At the time of my visit in November last, operations were being carried on along a small gully known as Ruby Gully, so named by reason of the presence of ruby tin in the washdirt; this gully heads on Mount Walker and runs through the middle of the lease, entering Parrot Creek on the right bank at a point some 5 chains down from the working face. This area had been previously worked about fifteen years ago by Messrs. Geo. Dunn and R. Grout, and subsequently by the present owners for the past ten years. The average depth of the ground is 25 ft.; there is usually much smaller stone in the wash on the shallower portions. The stone met with in the washdirt comprises sub-angular fragments of granite and quartz with a lesser amount of slate. The proportion of stone in the washdirt is relatively low. The overburden contains several layers of practically barren gravel. The bottom rock is hard slate and exhibits a somewhat uneven surface on removal of the overlying washdirt. As elsewhere on this lease the tinstone is more waterworn than is usually the case on the Annan tinfield. It is here of very high grade indeed, small parcels having re-

turned as much as 76·6 per cent., whilst large bulk lots have been sold on a 75 per cent. assay. The claim is being worked by means of an elevator, the power being supplied from a pipe column.

Water is obtained from Parrot Creek at a point just above Shipton's Falls and conveyed about 3 miles by earthwork, siphons, fluming and pipes. Some 600 ft. of wooden pipes and 250 ft. of 18-in. gauge iron were used on this work. There is always an abundance of water available. At the time of my visit a good two-sluice heads of water was coming down the race. The pipe column is of 12 to 8 to 6 in. in diameter, and operates a 6-in. nozzle with a 1¼-in. tip, and a 6-in. elevator. The material is elevated 10 ft. 6 in.; pressure, 100 ft.

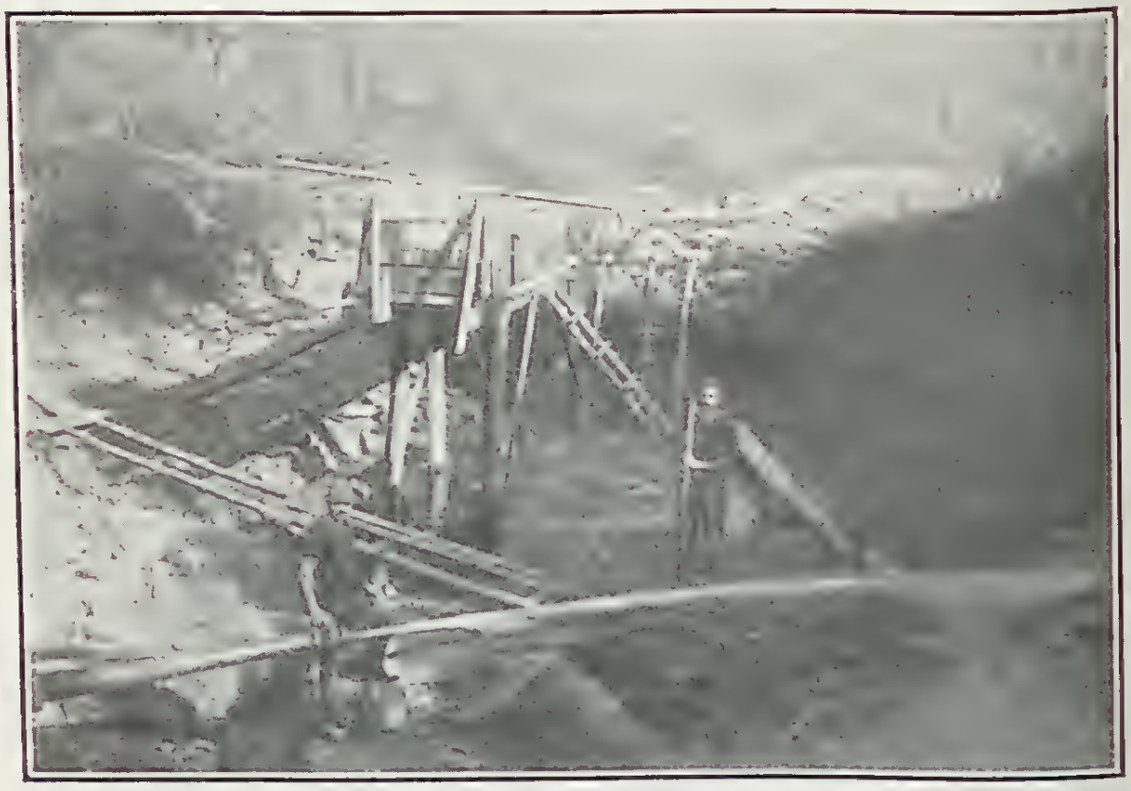
[*Photo., W. Horsfield.*

PLATE 23.—SHIPTON'S CLAIM (MINERAL LEASE 240.)

Showing the nature of the country and also "cleaning-up" operations.

Photographic views of this claim giving (1) the jet elevator released showing the water pressure available, and (2) constructing a siphon along the race, have already been published by me in the "Queensland Government Mining Journal" for March, 1915. The construction of the race occupied four men for two years. Including the two owners of the lease, a total of four men are constantly employed, working two shifts of eight

hours each. The sluice boxes are 60 ft. in length by 2 ft. 10 in. in width, with a " fall " of 4 in. per 10 ft. As in the case of the former workings near the southern corner of the lease already



[*Photo., W. Horsfield.*

PLATE 24.—ANOTHER VIEW OF SHIPTON'S CLAIM.

Showing nozzle and elevator at work.

described, it is found advantageous to use dynamite to loosen the overburden before attacking it with the nozzle. The washdirt is about 3 ft. in thickness, carrying practically all the tin values, particularly in its lowermost portion along the bottom. No tin has been found so far embedded in the bottom underneath the washdirt, as frequently happens elsewhere. At the present working place there has been roughly ¾ acre sluiced, and from the results obtained it is considered by the owners (1) that their best values are in the deeper ground, and (2) that no really distinct tin leads can be traced through the washdirt. It is their intention to continue sluicing up Ruby Gully next season, more especially along the right bank of the stream, in order to ultimately reach a point already sluiced up to from which very good returns have in the past been obtained in the bed of the gully. At the time of my examination of this area some 5 chains in width of a face had been exposed, but washdirt also continues strongly in the face going south-west (in the direction of George Shipton's claim adjoining on that side). Red cedar has been found the most satisfactory timber available for the races, par-

ticularly in the flumings, but fern-top or acacia cedar is almost exclusively employed in the construction of the sluice boxes.

During the year 1914 this claim turned out 8½ tons of tinstone, valued at £850, from 7,194 cubic yards of alluvial treated.

[*Photo., W. Horsfield.*

PLATE 25.—SHIPTON'S CLAIM.

Stripping the overburden by nozzle pressure.

Foreman's Claim.—Owned and worked by Geo. Jas. Foreman for the past five years; situated on the left bank of Parrot Creek, Shipton's Flat, and formerly worked by Symons and Dibney. The average depth of alluvium is about 10 ft. The bottom is uneven and of soft slate, on which rests some 18 in. of clayey washdirt carrying moderate tin values. There appears to be practically no tin through the overburden, the best values being usually found to exist at the very bottom of the washdirt itself. The tinstone is fairly fine, and black in colour, accompanied by a small amount of iron sand. Neither gold nor precious stones have been seen here so far. Water for sluicing is obtained from Parrot Creek at a point 1¼ miles upstream from the claim, the supply being efficient for nine or ten months in normal years. No leaders have been exposed in the slate bottom.

A fairly extensive area of ground yet remains to be worked on this property, the ground already sluiced being about 80 yards in length by 30 yards in width, in addition to which the owner has worked several areas immediately adjoining the present workings downstream. The washdirt consists essentially of slate detritus, admixed with which are occasional boulders of granite. A few chains north-westerly of the face exposed at the time of my visit in November, 1914, a limited area was worked by Messrs. Fellows and Nicholls for "surface" on top of the deep ground about ten years ago, but the results were not sufficiently payable to warrant further work owing to the limited extent of this deposit. It is considered locally that over 50 tons of tin in all have been won from the ground now represented by this claim, of which total the owner informed me he has obtained 7½ tons.

Horsfield's Claim.—Closer to Parrot Creek and downstream a short distance from Foreman's claim, Wm. A. Horsfield worked a limited area about seven years ago, but further work was impossible without having resort to methods other than hand work. The 10 to 12 ft. of alluvial here rests upon an uneven slate bottom.

Uncle Eddie's Show.—Owned by E. Shipton, and situated on Coronation Gully, a right bank tributary of Parrot Creek, which latter stream it joins close to the south-west corner of M.L. 240. The gully heads in Mount Walker Range and flows in a fairly straight south-west course along a narrow channel. Coronation Gully has been worked from a point about 10 chains up from the junction of Parrot Creek for a total distance of a quarter of a mile, the alluvial being extremely narrow owing to the generally defile-like nature of the gully channel. The bottom is of hard slate and very uneven, and is overlain by an average of 10 ft. of alluvial along the banks. The alluvial deposit is composed mostly of stone with a lesser amount of red clay. Tinstone occurs throughout this material but is present in most payable quantity in the lower 1 ft.

Water for sluicing is taken from Shipton's Claim (M.L. 240) race at a point half a mile distant from Uncle Eddie's Show. There is usually sufficient water available for sluicing. The tinstone is very coarse, and much of it is in the form of "specimens," the latter occurring with both slate and granite. It is black in colour. A quartz leader carrying tin was met with in the upper portion of the workings, strike north and south, width 3 in. Work has been in progress here for the past nine years, and it speaks volumes for the energy of the owner that he, an elderly man with one arm, should have been able to do so much in

ground where nearly every other stone met with in an extremely stony deposit should, on account of its size, have to be thrown out and stacked to one side by hand.

Tinstone, accompanied by rich (granite) specimens, has been recently traced up a small left branch "blind" gully at the top of the workings, the specimens indicating the existence of tin in the formation in the slate country at points where veins of sericitised aplitic granite intrude that rock. It is intended to continue working the main gully upstream, as payable values are known to occur about 3 chains above the present working face at a point where the sharp bend round to a left-hand branch gully occurs. Coronation Gully was partly worked by Wm. Sykes in 1913. The strike of the slates is north-west south-east. Much of this rock has been altered to a quartzite by the granitic intrusion and acid veins offshooting therefrom. The tinstone does not appear to occur for more than a few feet into the banks on either side of this steep gully, particularly at the site of present operations. Large boulders of quartz-diorite occur through the washdirt, but this rock is not definitely known to outcrop in this portion of the field, and the boulders in question most probably represent material from a denuded intrusive dyke.

Uncle George's Circus.—Owned by George Shipton; situated on Coronation Gully, adjoining Uncle Eddie's Show downstream and close to the western side of M.L. 240. At the time of my visit operations were being carried on along the banks of the gully. The average depth of the alluvial being worked is about 12 ft., the bottom 4 ft. being considered for practical mining purposes as the true washdirt, but all the material is distinctly gravelly and contains much stone (slate). Water for sluicing is obtained by arrangement from the main head race belonging to M.L. 240. The bottom is of hard slate. The tinstone is similar in every respect to that won from the adjoining lease just named.

Work has been carried on by the present owners during the past nine years, but the area was also worked to a small extent previous to that time. The owner intends to gradually sluice up towards the boundary of M.L. 240, as a considerable area of payable alluvial exists in that direction from his present working face. Sluicing is carried on by means of a 5-in. nozzle with 1½-in. tip. The best tin values obtained to date were found about the centre of the workings.

In addition to the area referred to as still remaining to be treated, a fair amount of workable ground occurs on the downstream side between the present workings and the junction of

Coronation Gully with Parrot Creek. I am informed that some 3½ tons of tinstone have been won here from 3,000 cubic yards of alluvial treated.

Symons and Downe's Claim.—This claim, not now being worked, was opened up by Messrs. E. Symons and George Downe in very dense vine scrub on a gully (a tributary of Rossville (?) Creek*) about 100 yards below the bridle track from The Bald Pocket to Shipton's Flat, and close to an old garden. The claim yielded about 27 bags of tin to the first owners, who then disposed of it to Sadler; ultimately it passed into the hands of William Casement. A tail race 100 yards in length was shot through a hard granite bar. The tinstone was here of high grade and mostly waterworn, but lower down in Rossville Creek it is much finer grained and not nearly so high as regards assay value. The granite bedrock here is very soft usually, the rock being of normal type with some muscovite. The limited area of alluvial available, the extreme softness of the bottom, the small water supply, the number of granite boulders met with, the density of the scrub in which it occurs, &c., combined to render this property too unattractive to warrant further work being done upon it.

Mary Claim.—M.L. 234 (10 acres); owned and worked by Simon Spargo; situated alongside the track from Rossville to Shipton's Flat, at Tabletop, on a small gully close to Spargo's house, the gully joining Parrot Creek near the southern boundary of the lease. The average depth of the alluvial deposit is about 20 ft., the lower 10 ft. being considered as washdirt. The bottom is of soft granite and fairly even in slope. A moderate amount of forking stone occurs through the wash, the rocks represented being mainly slate and quartz.

The tinstone is waterworn and is mostly black, with a little ruby and grey tin; assays up to 75½ per cent. have been obtained, but the average is stated to be 74 per cent. No gold has been seen here hitherto. A small blue stone from this claim, thought by the owner to be blue tin, was determined by me as being a sapphire. Occasional specimens of "grass stone" (rutile in quartz) are also reported to have been seen in the washdirt.

A width of face at least 60 ft. across had been exposed at the date of my visit in November, 1914, but a greater width undoubtedly exists. The best tin values have so far been obtained from the bed of the gully. The distribution of values through

* Not to be confused with another well-known creek of the same name in the Rossville district flowing through the Annan River Company's ground.

the washdirt is inclined to be patchy, but on the whole the tin may be said to lie close to and actually on the bedrock, and an elevator has to be used for that reason.

Water is obtained from Parrot Creek (two heads) and Rossville Creek (three heads); only two heads from Rossville Creek are available for hydraulicing, the pressure being 70 to 100 ft., whilst the balance gives a pressure of only 50 ft. at the face. Each of these two head races is a mile in length, of which a total of 7 chains of fluming 10 ft. in average height have been constructed. The pipe column reduces from 14 to 7 in.

Approximately half an acre of the alluvial within the lease pegs has been stripped to the top of the washdirt, but none of the latter has yet been raised. When seen by the writer, sluicing was in progress on an extended alluvial claim adjoining the northern boundary of the lease, and the gully has here been worked up for a distance of, roughly, 15 chains and to a width of about 100 yards. The alluvial wedges out from about 2 ft. in depth along the right bank to 15 ft. in the bed of the gully; the left bank appears to be an extension of deep ground. The owner informs me that 28 tons of tin have been recovered here during the past seven years. For the last three and a-half years a nozzle and elevator have been employed, but previous to that time work was carried out by hand methods. Owing to the rather cemented character of the overburden, an average of six cases of dynamite are used per annum to render this material easy for sluicing with the water pressure available. It is intended to work M.L. 234 during 1915; all the ground to be treated here will necessitate the use of an elevator by reason of the flatness of the claim. No boulders have been met with so far in the washdirt.

At the lower end of the lease a bar was shot through hard quartzite traversed by dykes of intrusive granite; the cost of cutting this tail race 4 chains in length and 6 ft. deep was £100. Pieces of solid mispickel (arsenical pyrites) are occasionally found when sluicing, as in the case of the Annan River Company's ground at Rossville. The Recent geological age of the deposit is indicated by the finding of rather numerous stone tomahawks embedded in the washdirt.

Spargo also worked a small area close to his house on the left bank of a gully known as *The Swamp*. The Swamp is a left bank tributary of Pearce's Creek. Average depth of alluvial worked, 12 ft., but the thickness of the overburden increases noticeably upstream towards his present workings. The tinstone is similar in occurrence and character to that on

M.L. 234. He obtained about 1 ton of tinstone, but the area was also profitably worked in the early days. The bottom is of decomposed granite.

The Warden reports that for the year ending 31st December, 1914, Spargo's claim produced 3¾ tons of tinstone, valued at £375.

Agnes Claim.—Worked by Neil Jenkins; situated at Table-top, near the left bank of Parrot Creek and opposite Spargo's claim. The average depth of ground being worked is about 10 ft., the deeper portion being situated on the upstream side. Water for sluicing is obtained from Horan's Creek at a point 1 mile distant from the workings. Horan's Creek rises near the summit of Mount Finlayson and joins Parrot Creek a quarter of a mile below the claim. Very little pressure is available with the race at present in use; approximately a sluice head was coming down the race when this property was seen by me in November, 1914, the water being directed on to the face with an ordinary fire hydrant. The tinstone is both coarse and fine in grain and varicoloured. The bottom rock consists usually of decomposed slate, and is immediately overlain by the richest tin values, very little tin occurring through the overburden. A number of granite boulders are met with in the overburden. Owing to the clayey and cemented nature of much of the face, explosives are employed. An area of about one-third of an acre has been worked to date. The average number of men employed has been three.

A total yield of 9 tons of tinstone, assaying from 75 to 76 per cent. in bulk parcels, is stated to have been made during the three years work has been in progress, and a considerable area of ground yet remains to be treated. It is intended to continue sluicing away from the creek in an easterly direction, but a nozzle and an efficient pipe column are needed. The tin values are somewhat patchy in distribution. The washdirt is sometimes cemented into blocks of conglomerate requiring burning in order to liberate the tinstone. Odd specks of scaly gold have been found here.

Buck Rock Claim.—Situated in granite country about half a mile by track up Bar Creek from Moore's house on the track to Shipton's Flat. This area was first worked by Simon Spargo about ten years ago. The mineral obtained by him was very coarse angular ruby and black tinstone, varying in size from rice grains to ¼-lb. slugs, and assaying from 74 to 76·8 per cent. During the two years he was mining here Spargo won a total of 7 tons of tinstone from a block of ground 300 ft. by 800 ft.

The ground was later on worked by Messrs. John Horan and Thomas James, but nothing has been done here for the past five years.

Water for sluicing was obtained from Pearce's and Rossville Creeks by a race 1¼ mile long, of which there were 3 chains of fluming; about two sluice heads are available for eight months of the year. Rutile was occasionally noticed in the quartz of the washdirt. Depth of alluvial about 5 ft., the lower 3 ft. being considered as the washdirt. Practically no titanic iron occurs here. A moderate amount of rock crystal is seen in the washdirt.

The washdirt comprises mainly boulders of granite and quartz, resting upon an uneven granite bottom. Several small quartz leaders occur through the bottom, strike E30°S.

A few chains to the north of Buck Rock a moderate amount of work has been carried out intermittently for some years past along a small watercourse known as Lost Gully. The values here are, it is understood, payable, but the scarcity of water for sluicing precludes the idea of working the ground continuously for any appreciable length of time.

[*Photo., R. Graff.*

PLATE 26.—LION'S DEN HOTEL, HELENVALE.

Note the large mango-trees which surround the building, as also the wagon-load of pipes *en route* from Cooktown to the Annan River Company's property at Rossville.

The above notes on Buck Rock have been furnished by my assistant, Mr. Roy Graff, who visited the area in January, 1915.

Helenvale.

That portion of the district known as Helenvale is situated some 21 miles by main road from Cooktown, at the junction of Mungumby Creek with the Annan River.

The good bush hotel located at a point one-third of a mile south-south-east of the road crossing at Mungumby Creek, on portion 34v, is of great convenience to travellers *en route* from Cooktown and Trevethan for Rossville, Grasstree, Bloomfield, The Tableland, &c.

Along Mungumby Creek and the Annan River hereabouts are moderately dense vine scrubs, but elsewhere in the neighbourhood the country would be classed as open forest land.

The distances by road from the Lion's Den Hotel here are as follows:—Rossville, 6 miles; Grasstree, 16 miles; Shipton's Flat, 10 miles; Tableland, 5 miles; Trevethan Hotel, 8 miles; Romeo, 17 miles. The aneroid reading here is 330 ft. about sea level, or 170 ft. lower than that of the village of Rossville. A moderately steep ridge of hills extends from Mungumby Creek, close past the southern side of Helenvale eastwards to The Tableland and a branch spur south-easterly to Wallaby Creek (Lower Tableland). From the junction near Nunn's butcher shop on Wallaby Creek with the Annan River (known as "The Forks") to a few miles below Helenvale, as also up Mungumby Creek to Young's old butcher shop, there exists a considerable area of alluvial material.

Slate covers the whole of the Helenvale area proper, though occasional granitic dykes, intruding that formation may be seen. Several hard bars of slate cross the river at intervals in this locality, and have materially helped in the deposition of the extensive alluvial deposits found here. Along the northern edge of the scrub on Mungumby Creek, on the Cooktown road, at a point half a mile north of the hotel, occurs an outcrop in the road-cutting of very highly-cleaved and schistose rocks showing a fair amount of chloritic material; strike north-north-west; dip west-south-west.

A prominent bar of quartzite crosses the river at a point immediately behind the hotel; the maximum width of the outcrop exposed here during dry weather is 5 chains. Odd specks of black oxide of manganese are dotted through the stone and along the joint planes. Strike 105 degrees, dip vertical. This rock probably represents a segregation of quartzose material from an intrusive granitic dyke into a sedimentary band.

[*Photo., R. Graff.*

PLATE 27.—SCRUB COUNTRY ALONG ROSSVILLE ROAD; ADJOINING THE ANNAN RIVER, NEAR NUNN'S FORKS, HELENVALE DISTRICT.

The Warden's returns of tin won from this portion of the field for the five-year period 1910-1914, inclusive, are as under:—

	Cwt.	qr.	lb.	Value. £	s.	d.
1910	5	0	6	24	15	0
1911	15	1	9	83	0	0
1912	1	3	14	10	18	0
1913	..			..		
1914	13	0	0	72	0	0
Total	35	1	1	£190	13	0

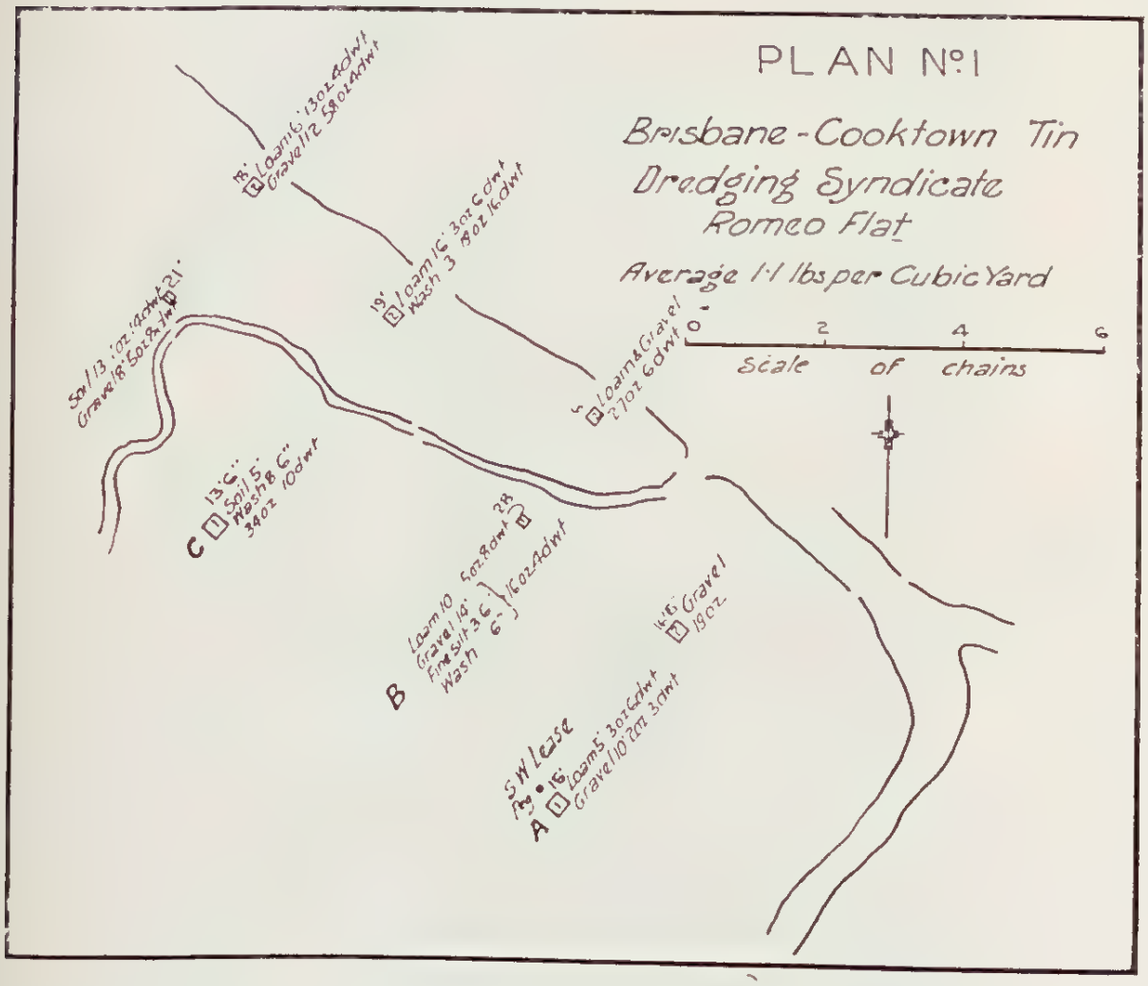
Brisbane-Cooktown Tin Dredging Syndicate.—George Goodman, local representative. M.L. 1180.

[*Photo., R. Graff.*

PLATE 28.—VIEW IN MUNGUMBY SCRUB, HELENVALE.

This syndicate has taken up a lease which extends along the Annan River from The Forks to well below the Lion's Den Hotel. In order to test the ground as thoroughly as possible, a considerable amount of prospecting has been carried out on the three principal flats included within the area, viz.:—Romeo, Bowditch's, and Mungumby Flats. **Romeo Flat** occupies the southern portion of the area, along the left (western) bank of

the Annan River, and several trial shafts sunk hereon are stated by Mr. Goodman to have given an average yield of 1·1 lb. of tinstone per cubic yard for the area tested. The maximum depth obtained here was 28 ft., the strata passed through being as under (shaft B No. 1, *vide* plan) :—



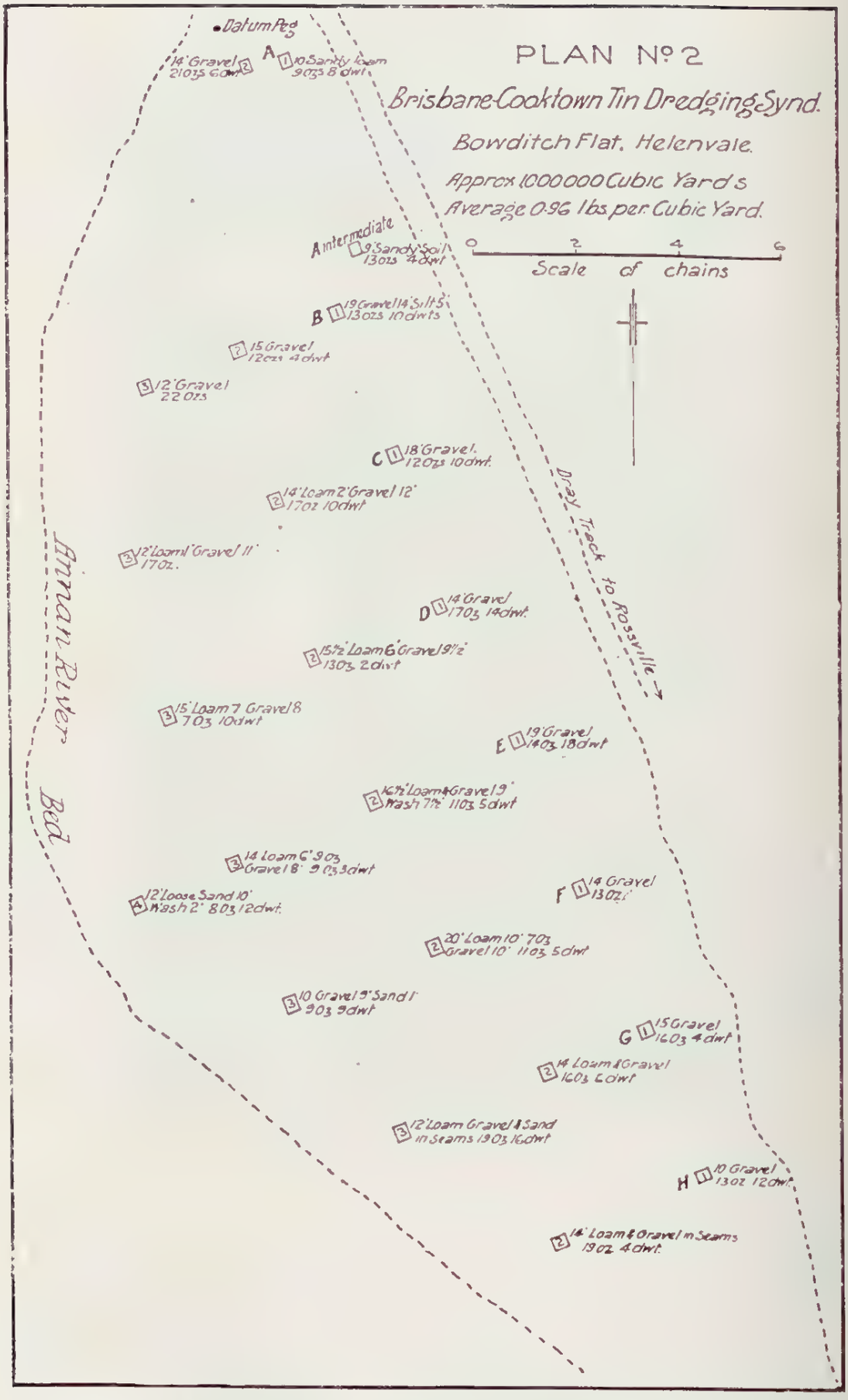
Loam ..	10 ft.	yielding 3 oz. 6 dwt.	of tinstone per cubic yard.
Gravel ..	14 ft.		
Fine silt	3 ft. 6 in.	„ 16 oz. 4 dwt.	„ „ „
Washdirt	0 ft. 6 in.		

A shaft sunk close to the south-west peg of the lease is stated to have returned (shaft A No. 1) :—

Loam ..	5 ft.	yielding 3 oz. 6 dwt.	of tinstone per cubic yard.
Gravel ..	10 ft.	„ 23 oz. 2 dwt.	„ „ „

A second shaft, situated about half-way between A No. 1 and the river bank, is stated to have resulted in 16 ft. 6 in. of gravel being pierced for an average yield of 19 oz. of tinstone per cubic yard.

In the case of the extensive area known as **Bowditch's Flat,** lying between the right bank of the Annan and the dray track to Rossville, a total of 25 shafts were put down at regular intervals apart and the strata noted. Mr. Goodman estimates that he has here proved an area containing 1,000,000 cubic yards of



dredgeable material of an average value of 0·96 lb. of tinstone per cubic yard. There is in addition a considerable area of alluvial ground lying on the eastern side of the Rossville Road

in this portion of the area. Thick beds of gravel characterise Bowditch's Flat practically everywhere. A typical shaft section

[*Photo., R. Graff*

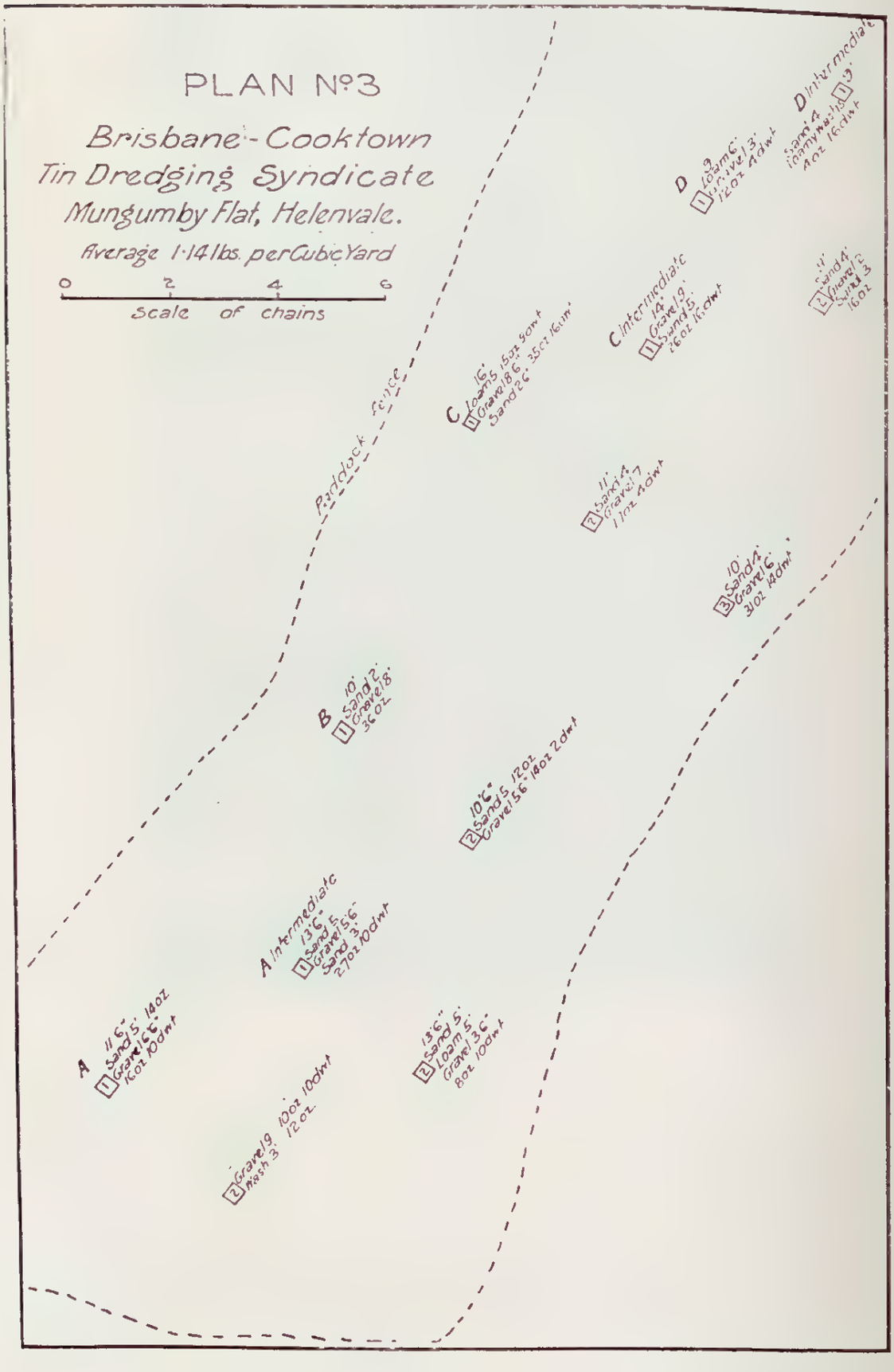
PLATE 29.—MUNGUMBY CREEK, HELENVALE.
View in scrub country close to the Cooktown Road.

is that furnished by shaft E No. 2, which occupies about the centre of the area tested:—

Loam and gravel ..	9 ft.	averaging 11 oz. 5 dwt. of tinstone
Washdirt	7 ft. 6 in.	per cubic yard.

In the case of the third area tested—namely, **Mungumby Flat**—the average yield is stated to have been slightly higher than in the case of either Romeo or Bowditch's Flats, the figures

given being 1·14 lb. per cubic yard. Some fourteen shafts were sunk on this flat through the sand and gravel beds in the area lying between an old paddock fence and the left bank of the Annan, below the hotel; a fairly typical shaft is C No. 2,


PLAN No3
Brisbane-Cooktown
Tin Dredging Syndicate
Mungumby Flat, Helenvale.
Average 1·14 lbs. per Cubic Yard
0 2 4 6
Scale of chains
Paddock fence
A 11'6" Sand 5' 1 oz Gravel 6' 1 oz 10 dwt
A Intermediate 13'6" 1 Sand 5' Gravel 5'6" Sand 3' 2 oz 10 dwt
2 Gravel 9' 1 oz 10 dwt Wash 3' 12 oz
B 10' 1 Sand 2' Gravel 8' 3 oz
2 10'6" Sand 5' 12 oz Gravel 5'6" 1 oz 2 dwt
2 13'6" Sand 5' Loam 5' Gravel 3'6" 8 oz 10 dwt
C 16' 1 Loam 6' Gravel 8'6" Sand 2'6" 3 oz 15 dwt
C Intermediate 14' 1 Gravel 9' Sand 5' 1 oz 15 dwt
2 11' Sand 4' Gravel 7' 1 oz 10 dwt
D 13' 1 Loam 6' Gravel 3' 1 oz 10 dwt
D Intermediate 13' 1 Sand 4' Ironmystone 9' 1 oz 15 dwt
2 11' Sand 4' Gravel 2' Sand 3' 1 oz
3 10' Sand 4' Gravel 6' 3 oz 10 dwt

situated approximately in the centre of the area tested. The returns from this opening are given as follows:—

Sand .. 4 ft. } yielding an average return of 17 oz. 4 dwt. of
Gravel .. 7 ft. } tinstone per cubic yard.

The average yield from all three flats is stated to have been 1·1 lb. per cubic yard.

Downstream, below the hotel, is a considerable area of alluvium, consisting of loose sand, loam, and gravel beds. Several dishes of dirt were washed for me along this alluvium belt and showed the ground to carry moderate tin values. Along the left bank of the river, in the alluvium, are several small lagoons, the edges of which are beds of gravel containing a fair quantity of tin associated with ilmenite. Immediately adjoining the aborigines' camp on the right bank of the river, at Helenvale, a cutting was put into the river bank by Goodman and exposed a thick bed of gravel, from which latter prospects washed for me showed payable values; fair values are also present in the sand overlying the gravel bed.

Towards the northern end of this syndicate's ground there exists a very extensive flat (at least 500 acres in extent) along the left bank of the river and extending back from the stream channel for about 12 chains or more. In several places later erosion along small tributary gullies has partly exposed this flat in section. At one such exposed portion, near the southern end of the flat, a bank of alluvium was tested for me by the sinking of a 5-ft. deep prospecting hole at the base of the cliff face. This hole passed through alternating thin bands of coarse red sand and brownish yellow washdirt containing waterworn gravel composed of tourmalinised granite, quartz, and slate. This material undoubtedly represents river-borne detritus. Many of the granite pebbles have been highly decomposed subsequent to deposition in their present strata and suggest therefore that the deposit is of considerable age. Lying on top of this true river-formed alluvium is a deposit of about 6 ft. of surface soil, which latter has in all probability been derived by denudation from the adjacent slate hills. Washdirt was still going down strongly in the bottom of the prospecting hole referred to, but the quantity of water encountered effectualy prevented the hole being deepened to ascertain the depth to and nature of the bedrock, &c. Average dishes from this hole gave a fair return of tinstone. A thickness of not less than 25 ft. of more or less stanniferous alluvium is proved here already, and if this material can be proved by further prospecting operations to extend over the

major portion of the flat it should prove an excellent dredging proposition if values—to be determined by exhaustive boring—are satisfactory. The flat is covered with open forest and the surface level averages between 30 and 40 ft. above that of the river. The wash stones where showing are mostly of small size, whilst the bulk of the alluvial consists of a coarse reddish to brown sand. An average sample of 2 ft. of the latter material from near the top of the deposit gave fair tin values in the prospecting dish. Very little ilmenite occurs here with the tin.

In places the gravel is somewhat tightly cemented, but taking the deposit as a whole the material should be fairly easy to treat by dredging methods.

A very deep hole occurs along the river bed in front of this flat previously referred to. It is some 2 miles in length and must of necessity have formed the settling ground for the fine tin brought down by flood waters. From the experience gained in the matter of treating the material deposited under similar conditions elsewhere—*e.g.*, Severn River in the Stanthorpe Tinfield, &c., it should be worth while, in view of the trifling cost entailed, to obtain samples of the sludge from various points along the bottom of this hole and test same for tin values.

Below this flat a hard bar of bluish coloured quartzite with seams of granitic quartz has been cut through by the river with the production of a majestic canyon-like track along which the water cascades at a great pace. This feature is well worth a visit by anyone who delights in good scenery, and is of interest in that the bar has held back both the large area of alluvium deposited on its upstream side and also hindered the wearing down of the river bed, which, if allowed to proceed rapidly, would have long since breached the lower end of the long waterhole referred to above.

At the time of my examination of this property, in September, 1914, I was informed by their representative that the syndicate intended carrying out further testing at a subsequent date. Owing to the quantity of water encountered in the shafts at a depth the bottom rock has not been seen in any of the openings with the one exception where a hard bar was met with on the northern end of Bowditch's Flat. The tinstone is mainly fine-grained and usually of a black colour, but lesser quantities of brown and grey tin, much resembling sand, have been met with. Odd "colours" of gold are seen but no gemstones have been hitherto recorded.

Mr. Goodman estimates that there are at least 4,000,000

cubic yards of dredging ground available on this property, and should the values found be sufficiently encouraging, I have no hesitation in accepting his figures as to the yardage available as being in no wise exaggerated. The stones met with are mainly small in size, there being a rather marked absence of the large boulders seen elsewhere, though, of course, such may possibly be found along the bottom when the latter is reached. It has been proposed to utilise water-generated electrical power, some 720 ft. of head pressure being obtainable from the Helenvale Falls on O'Keefe's Creek; the wires would need to be some 3 miles in length for this purpose.

[*Photo., W. Sykes.*

PLATE 30A.—WATERFALL IN THE SCRUB COUNTRY ALONG O'KEEFE'S CREEK, TABLELAND.

After heavy rains a noticeable amount of fine tinstone can be observed on top of the alluvial forming one or other of the extensive river beaches occurring here. Portions of the stream bed

have in the past been ground sluiced during the dry season when the river is low, notably just below the hard slate bar close to the hotel. A water race was brought some 2 miles to work Bowditch's Flat in the early days of the field. The area under review constitutes the settling ground for a large portion of the material transported by the Annan River and its tributaries, and a considerable amount of tin has probably been brought down in this way. The

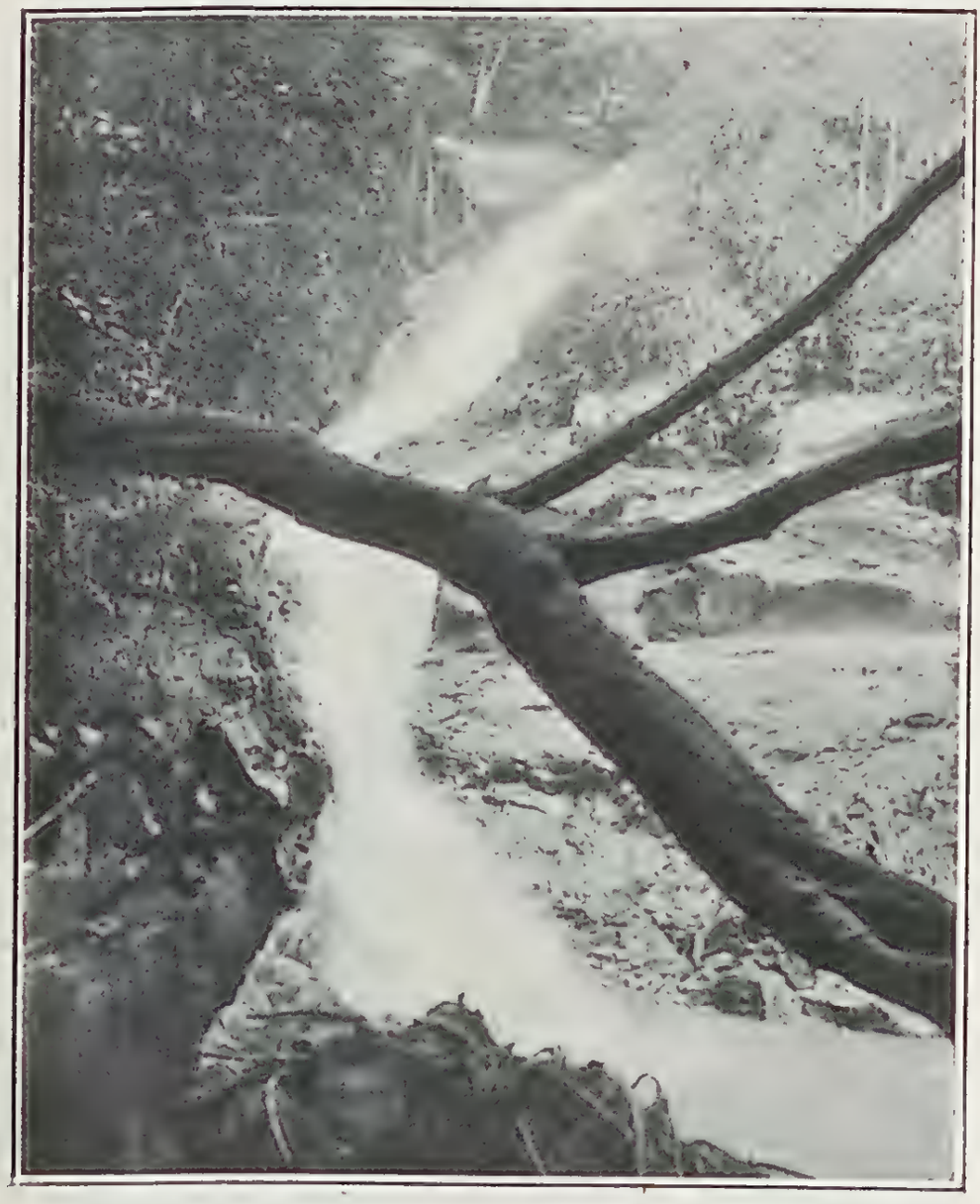
[*Photo., W. Sykes.*

PLATE 30B.—WATERFALL IN THE SCRUB COUNTRY ALONG O'KEEFE'S CREEK, TABLELAND.

great thickness of alluvial met with suggests that there may have existed, at a former period, a lake or depression such as a chain of large waterholes in which the alluvium was gradually deposited, the river now cutting its way down through the accumulated material along slightly different directions to the original channel resulting in the striking of bars of slate.

It has been observed that the wash stones occurring in the

lower levels consist of a much greater proportion of granite than is the case nearer the present surface, where slate fragments predominate. At several places, particularly along the left bank of the river, a "false bottom" shows near the water level; this formation has been mistaken for a decomposed true bottom until quite recently, when prospecting operations by the present syndicate revealed the presence of washdirt beneath it. No danger need be apprehended from mine timbers buried



[*Photo., W. Sykes.*

PLATE 30C.—WATERFALL IN THE SCRUB COUNTRY ALONG O'KEEFE'S CREEK, TABLELAND.

below the surface, as the conditions obtaining here effectually precluded work being carried on in the early days below the water level. I am informed that practically no buried timber to speak of has been seen in any of the numerous test shafts sunk whilst prospecting by the present owners. By so regulating the work that the plant could be operating on the banks during

the rainy season, there seems no reason why this area could not be effectually handled with a bucket dredge throughout the year, though precaution against sudden floods, to which this region is subject, would need to be made.

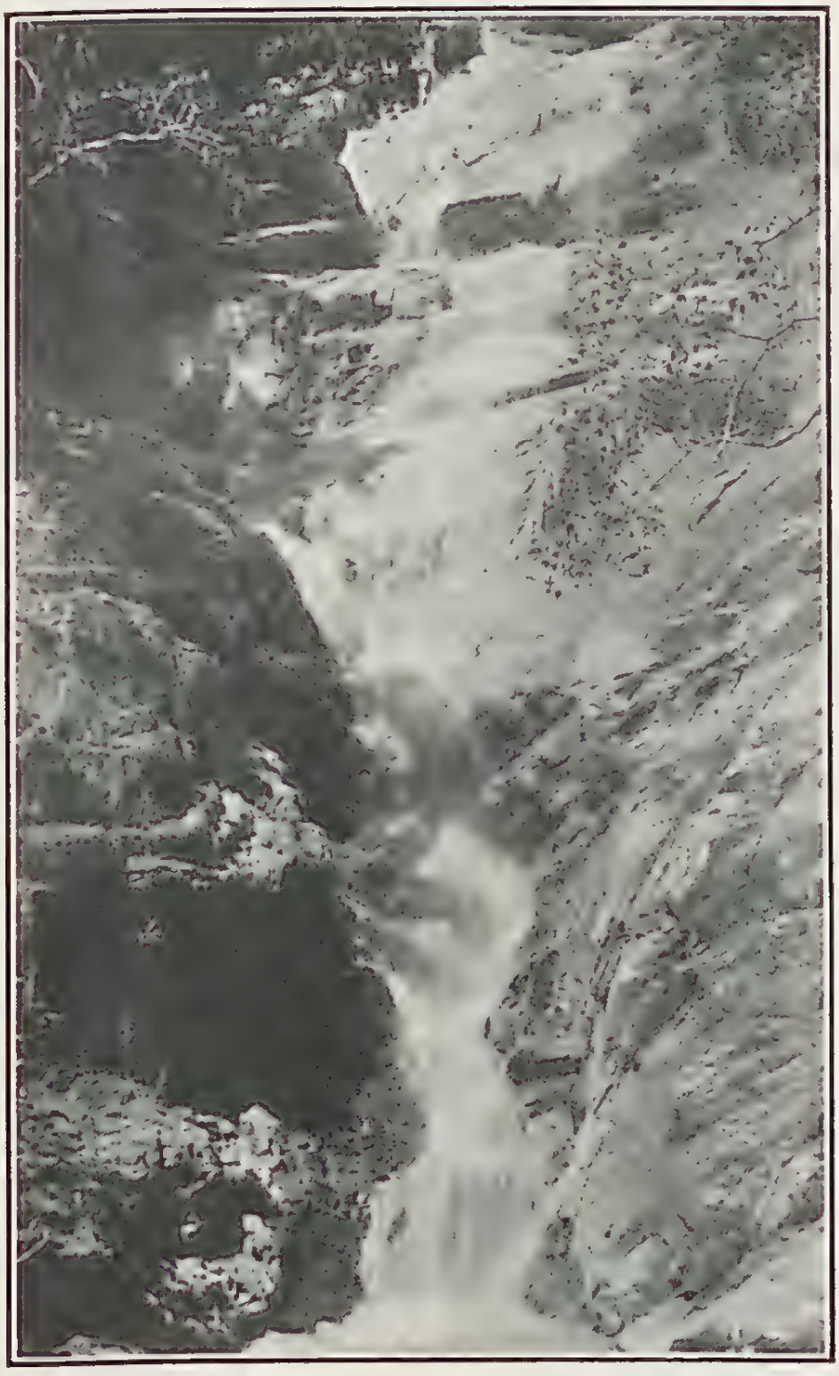
In view of the rather excessive amount of black sand accompanying the tin, the average stated values per cubic yard of the material tested to date should, in my opinion, be accepted with some reserve. The safest way to proceed in ascertaining the actual

[*Photo., W. Sykes.*

PLATE 30D.—WATERFALL IN THE SCRUB COUNTRY ALONG O'KEEFE'S CREEK, TABLELAND.

quantity of tin would be to have the concentrates from each shaft assayed for metallic tin and then calculate the result back to tin oxide, as was done when sampling the Annan River Company's property. That such an extensive area of workable alluvial within easy reach of Cooktown should remain idle for so long,

despite the fact that it has been previously tested by several experienced men, makes it all the more necessary for those in search of dredging properties to exercise caution before spending any very large sum on a bucket dredge or other machinery for this area.



[*Photo., R. Graff.*

PLATE 31.—HELENVALE FALLS, MUNGUMBY CREEK, THE TABLELAND.
In hardened slate and granite at the contact of these formations.

THE TABLELAND.

The area known as The Tableland (and formerly as Mount O'Keefe) is an elevated portion of the district occupying the high land drained by Mungumby Creek from the junction of which

stream with the Annan River it is distant about 5 miles in a due easterly direction. As will be seen by the following list of aneroid level readings, the ground rises very sharply over the latter end of the track. Helenevale Hotel, 330 ft.; Young's old butcher shop, 490 ft.; O'Keefe's Creek immediately above the Helenvale Falls, 1,200 ft.; Lion's Den workings, 1,650 ft.; McIntosh's house, 1,750 ft.; Jones's Camp, 2,090 ft.; McLean's Camp, 2,280 ft.; The "Look Out," 2,330 ft. The stream draining this area is known as Mungumby Creek for that portion of its length only below the junction of the two main tributaries—O'Keefe's or Fitzroy Creek and Mackie's Creek—the right and left branches* respectively.

The more elevated portions of the Tableland are covered with dense vine scrub, the scrub being notably extensive along the southern portion in the neighbourhood of The Look Out. The Look Out is situated just below the summit of the southern slope of the very steep ridge overlooking the village of Rossville to the southward. A clearing has been made by Messrs. Jones, Sykes, and others in the dense scrub hereabouts for the convenience of visitors, and a splendid view is obtainable of most of the area described in this Bulletin. Visitors to the tinfields who can spare the time should certainly make the trip to this point, as the view well repays the rather stiff climb entailed.

Along O'Keefe's Creek are numerous waterfalls, some of them being of notable beauty. The accompanying views (Plates 30 A, B, C, D) show a few of these features met with in the upper course of the creek. The water is usually delightfully cool and clear and is of excellent taste—particularly along that portion of the stream course which is through dense scrub in granite country. O'Keefe's Creek heads in the high hill known as Madam Berry.

The contact of the slate and granite in this area follows the stream channel of O'Keefe's Creek with remarkable persistency, the northern portion (right bank) being slate whilst the remainder of the area is granite. The junction of the slate and granite is also well shown at the Helenvale Falls, situated on this creek at the western edge of The Tableland country (Plate 31).

* Everywhere in the Cooktown district, and, indeed, throughout the State, I found that considerable misconception often exists as to what constitutes the right and left banks of a stream, the general impression being that the point is determined by the observer looking upstream, whereas, of course, the opposite is the case. In other words, to determine on which bank of a stream any place is situated, the observer should face in the direction in which the water is flowing.

The contact between the sedimentary and granite rocks can be well seen in O'Keefe's Creek a few chains upstream from the site of the old Lion's Den crushing plant. Both the slate and the granite are here traversed by a network of quartz veinlets, many of the latter showing miniature faultings. The slate presents strong cleavage lines striking in a direction rudely parallel to the line of contact. The slates are mostly blue in colour and intensely hardened by the intrusion of the granite into a quartzite rock closely resembling basalt at first sight.

The accompanying sketch (Figure B) gives a characteristic structure seen in the stanniferous granites along O'Keefe's Creek; the particular locality at which this drawing was made being in a small cliff face adjoining the waterfall above the site of the old Lion's Den crushing plant. It will be seen that the granite on either side of the lens of quartz becomes gradually more acidic in type until it finally passes into pure quartz, and in the central portion of the quartz lens are lenses of tourmaline.

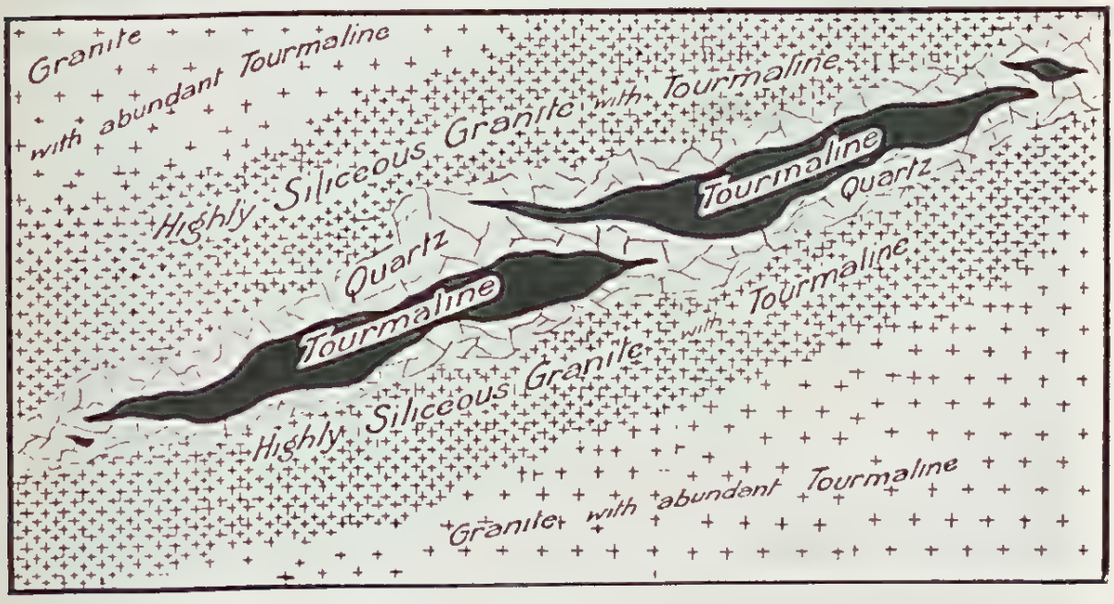
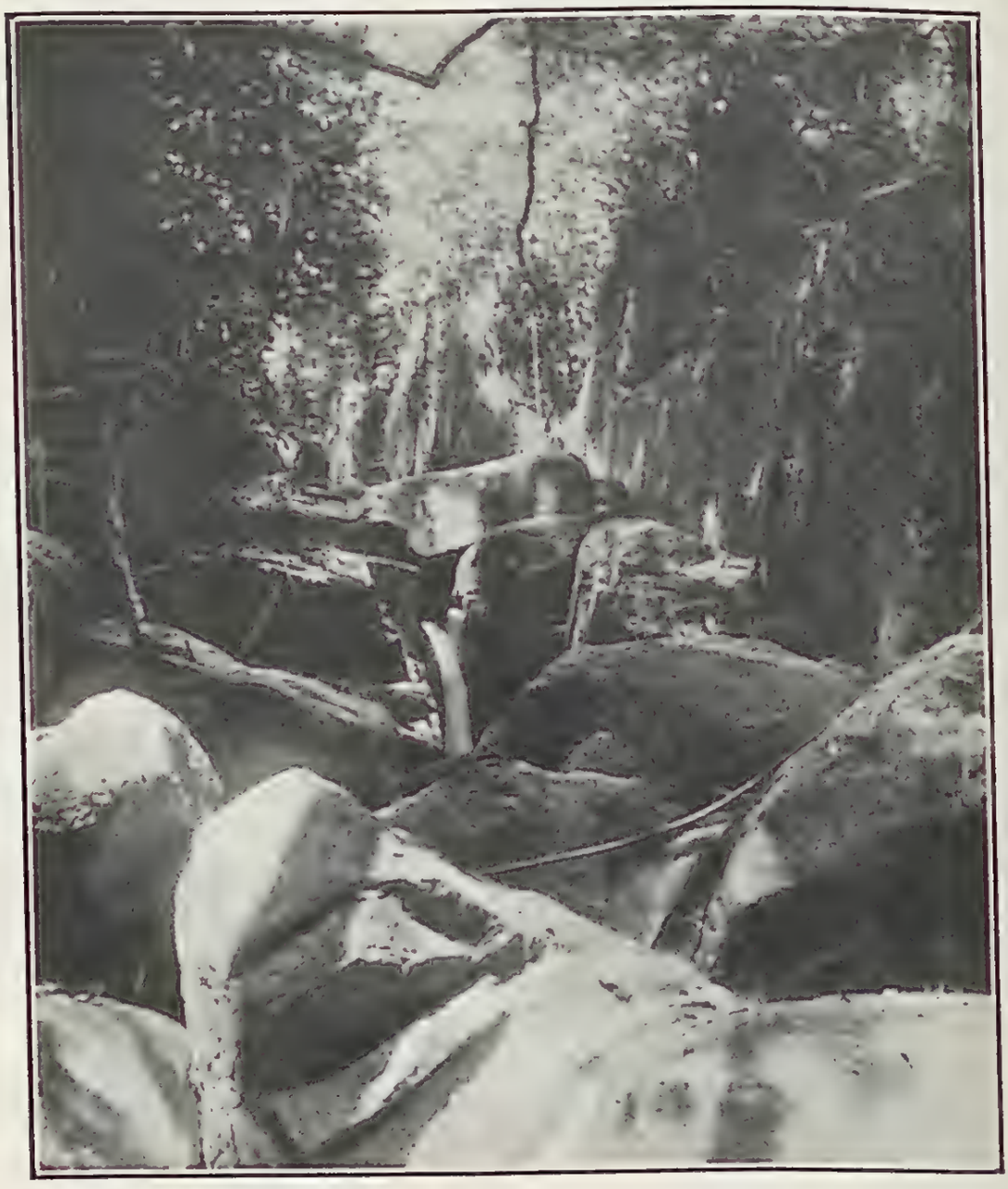


Fig. B.—A Characteristic Structure seen in the Stanniferous Granites, O'Keefe's Creek, Tableland.

Mackie's Creek, the left branch of Mungumby Creek, flows through scrub country for most of its course; numerous small waterfalls and cascades occur along it, the prevailing rock feature being huge boulders of granite. Plates 32 and 33 give typical views of this creek.

In the Reserve adjoining portion 54v, the slate-granite contact may be seen in an upper branch of Trevethan Creek at the Lower Falls; the intrusion of tongues of granite into the slate has here produced an extremely hard rock resulting in the production of the hard bar across the stream over which the water

falls. These falls are about 18 ft. in height and below them is a small but very deep hole. About four ground-sluice heads of water were coming over the falls at the time of my visit in October, 1914. The slate is here practically vertical and shows remarkably well developed lines of cleavage dipping E20°S at 35 degrees. The granite is somewhat more acid than the normal type and medium grained. Numerous veinlets of



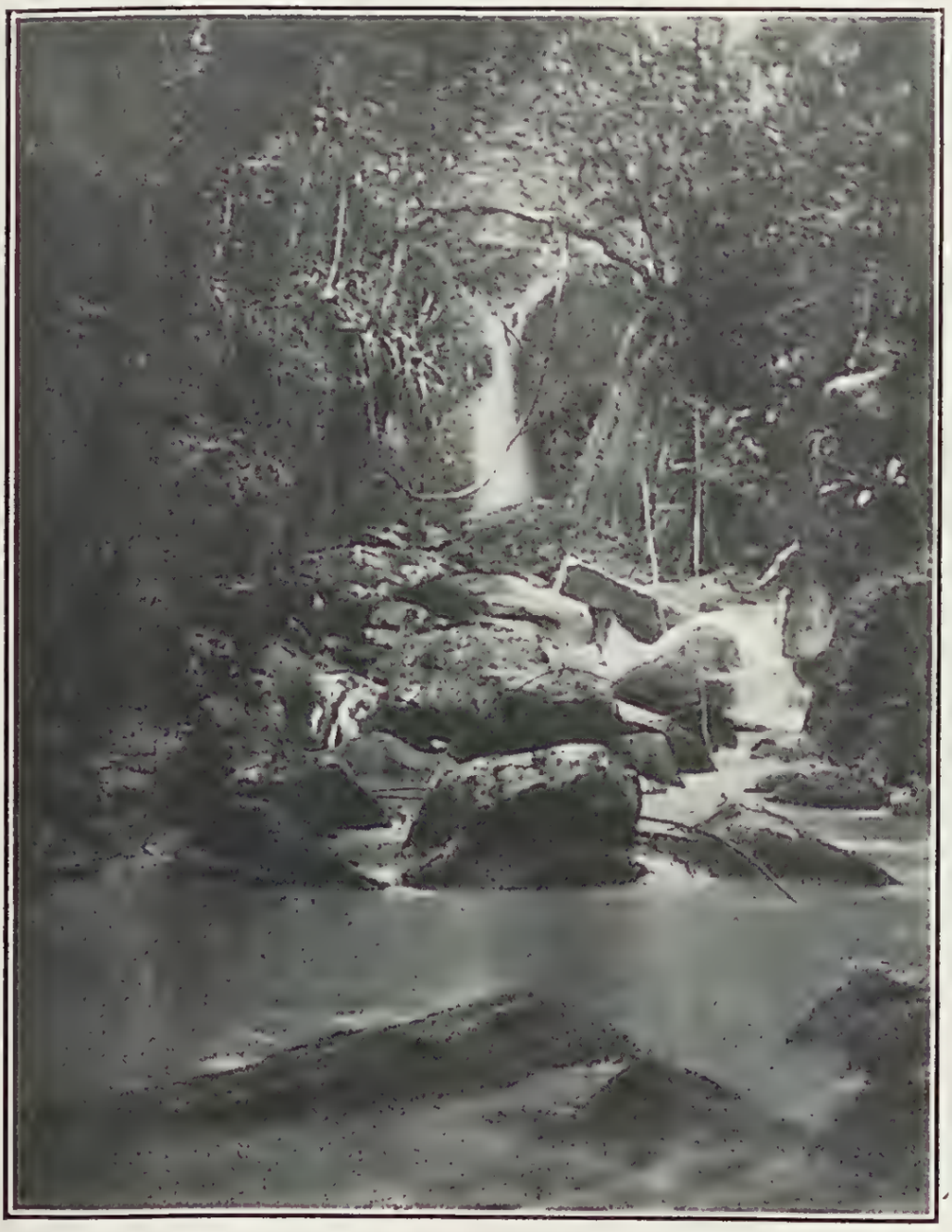
[*Photo., W. Sykes.*

PLATE 32.—GRANITE BOULDERS IN THE BED OF MACKIE'S CREEK, TABLELAND.

quartz traverse the slate at the contact. The contact line is sharply defined and shows as a perfectly straight wall at times. Immediately above the falls occur several quartz veins in slate, averaging 1 in. in width and exhibiting an east-west strike. The stream follows the contact with wonderful regularity to near the

Top (main) Falls. Near the marginal line may be observed many smooth faces of bare rock (slate) dipping S30°E at an average angle of 20 degrees.

The Top Falls are in schistose slate, the schistosity being due to the granitic intrusion, the latter rock outcropping upstream above the falls as a fine-grained rock traversed by veins of quartz and tourmaline, striking S20°E. The track (now practically grown over) from the Top Falls to The Tableland proper passes over a high, densely scrub-covered ridge and near the watershed between this creek and O'Keefe's Creek, excellent views of the ocean are obtained from vantage points.



[*Photo., W. Sykes.*

PLATE 33.—FALLS IN SCRUB COUNTRY ALONG MACKIE'S CREEK, TABLELAND.

The Warden's returns for the five years ending 31st December, 1914, give the following yields:—

	Tons	cwt.	qr.	lb.	Value. £	s.	d.
1910	10	16	1	8	1,030	0	0
1911	3	6	4	0	372	8	0
1912	10	10	1	21	1,294	0	0
1913	10	6	0	25	1,203	10	0
1914	6	10	2	23	623	12	0
Total ..	41	10	2	21	£4,523	10	0

Lion's Den Claim.—A considerable amount of lode mining has been done here in the past, and much machinery was erected for the purpose. In more recent years, however, work has been practically limited to sluicing operations. Only one claim was being worked at the time of my visit in September, 1914—namely, that owned and worked by Evan McIntosh, on the old Lion's Den lease, M.L. 186, about 5 miles by track from Helenvale. McIntosh uses a 7-in. pipe column and a small nozzle, with 80 ft. of pressure, to treat "surfacing" lying along the western edge of the steep hill on which the workings are located. Water is obtained from O'Keefe's Creek at a point some 20 chains upstream from the present workings. The race includes 4 chains of iron fluming. The depth of the surface deposit is from a few inches to 12 ft., the material consisting of granitic sand with very numerous large boulders of granite. The tinstone is inclined to be patchy in its occurrence. Numbers of small tin leaders of irregular strike are seen to traverse the granite, and occasional seams of nearly pure tinstone are met with. There is an excellent getaway for the tailings below the area now being sluiced. The tinstone assays from 65 to 68 per cent. as sold in bulk parcels, but could be readily cleaned up to yield an assay of 70 per cent. if need be. Much of the mineral won has a distinctly "reddish" tinge and is of fine grain, though occasional blocks of specimen tin and nuggets up to 50 lb. in weight are stated to have been obtained. No gemstones have been met with up to the present hereabouts. The present owner has been working here for the past three years, during which period he has had up to six men employed on occasions, but latterly has been carrying on the work without assistance.

The granitic soil in the neighbourhood is thickly overgrown with oak trees. T. F. Ross opened out a small cutting with a nozzle about 8 chains distant in a direction S20°E from the present workings. The granite is here very decomposed to a depth of at least the 20 ft. exposed, and is traversed by veins of tourmaline and tin-bearing quartz. This ground was too poor

to warrant further work; the tin obtained was very fine-grained, with occasional small nuggets. Strike of the tin-bearing veins 300 degrees; dip S30°W at about 60 degrees. The granite rock itself hereabouts carries an unusually large amount of tourmaline. In the case of the leaders referred to, it frequently happens that the central portion of the vein is of bluish semi-transparent quartz, the tourmaline being situated along the outer edges.

I am informed that some 4 tons of tinstone was obtained many years ago from a leader worked down to a depth of 30 ft. in the shaft close to McIntosh's house; the strike in this case is 345 degrees, dip vertically. The stone carrying the mineral consists of cavernous highly tourmaline-bearing quartz. The "surfacing" around the shaft was particularly rich, notably along the western fall. At a spot about 4 chains north-west of McIntosh's house, an occurrence in many respects resembling a "pipe" was worked to a shallow depth and gave a satisfactory return. The present owner and others have also obtained a moderate quantity of tin from very shallow "surfacing" hereabouts. The rock is here mainly even-grained quartz and felspar with tourmaline.

Immediately below the last-mentioned outcrop, and close to O'Keefe's Creek, McIntosh worked a leader composed essentially of felspar with lesser amounts of quartz and tourmaline; strike 344 degrees; dip vertical. This leader was worked for a length of about 30 ft. and to a depth of 8 ft; rich tin specimens were obtained from this cutting. The lode material was decidedly soft and occurred in a decomposed granite traversed by a network of quartz leaders. The steep hillside along the southern bank of O'Keefe's Creek has been for the most part sluiced for "surfacing." The granite in this section of the area is decomposed to a depth of at least 30 ft., and tin-bearing leaders exhibiting a north-south trend have been exposed in several places. The upper portion of the decomposed rock is usually much harder than those portions not actually at the surface owing to surface hardening due to deposition of iron oxide, &c., amongst the decomposed granite material. Pieces of amethystine quartz are fairly abundant among the stone heaps about the old workings. Some £36,000 is said to have been spent here originally by the former company on machinery, tunnels, tramlines, &c.

Dr. Jack, who visited this area in 1890, gives the following account of the rather extensive work that had been carried out in the early days of the field*:—

* G. S. Q. Publication No. 66, pages 5-7.

"The Lion's Den group of mines is situated on the head waters of Mongumby Creek, which falls into the right bank of the Annan about 2 miles north of the junction of Wallaby Creek and the river. A dray road leads from Platt's public-house, near the mouth of Mungumby Creek, and follows the creek up on its right bank to Robbin's slaughter-yards, a distance of about 3 miles. At this point the road commences to ascend the range by a very steep grade, and the mines are reached in about 1 mile more. The topmost mines are situated on the crown of a spur of the so-called 'Tableland,' at an elevation of about 1,760 ft. above the sea. The ore-dressing machinery is on the left bank of Byers' Creek (one of the heads of Mungumby Creek), at an elevation of about 560 ft. lower.

"The road from Platts' to Robbins' apparently traverses a country rock of slate and schist, although, owing to the accumulation of alluvial deposits the bedrock is rarely seen. In ascending the range the road crosses micaceous grey slates and greywackes. Where the road crosses Byers' Creek, about 400 yards below the machine, altered coarse-grained quartzites are seen. From this point up the spur to the mines the country rock is a peculiar granite, in which schorl* apparently takes the place of mica, although it is not regularly distributed throughout the felspatic and quartzose matrix, but has a tendency to be grouped together in 'nests,' which on weathered surfaces present the appearance of pebbles in a conglomerate.

"Shaft A, on the crown of the ridge near the south-east corner of Lease 43, is 60 ft. deep. I found that it had been timbered to the 30-ft. level, and consequently I could see nothing of the lode; but the manager informed me that the latter was followed in the shaft to a depth of 29 ft., when it went out of the shaft, having a slight underlie to the south-west. At 30 ft. a level connects Shaft A with Shaft B, the horizontal distance being 97 ft. In this level the country rock (of granite, such as is described above) can be seen on both sides. The bearing of the level is north 8 degrees west (magnetic). The ground has been stoped out from the level to the surface, the ore, according to the manager, having been carried by a soft 'porphyry' intersecting the granite. Twenty feet north of Shaft B in this level a branch lode left the main lode on a course slightly more to the west, whilst the main lode continued up to the surface. Fifty-seven feet beyond Shaft B, a pass goes up to the surface, from the level (12 ft.), and down the underlie of the lode to a level 30 ft. beneath. Seven feet beyond the pass (3 ft. short of the face) I saw a decomposing felsite or porphyry, 9 in. in

* Schorl is the black variety of tourmaline. See page 163 (E.C. St.S.).

thickness, about half its mass being composed of tourmaline with some tin ore. About 15 ft. back along the level from the pass, I obtained from the floor some specimens of 'soft' porphyry spotted with fine crystals of cassiterite. Specimen No. 57 yielded, on assay, 5·4 per cent., and Specimen No. 58, 11·4 per cent., of metallic tin. It may be mentioned that the specimens bear a great resemblance to some specimens from the 'White Face' at Mount Bischoff, in the Geological Survey Museum.

"These two were the only places where the tin-bearing stone could be seen in the level, the ground above being for the most part stoped out.

" The 60-ft. level, extending from Shaft A through Shaft B, has been carried to a total distance of about 370 ft. from Shaft A. This level will be referred to under the head of 'No. 1 Tunnel.' Shaft B has been sunk to the 60-ft. level of Shaft A.

"The lode can be traced as a streak on the surface for some distance down the hill to the north. The 'porphyry' of the lode is a mass of decomposed felstone, with fine quartz blebs and lumps of tourmaline weathering out like pebbles. Between Shaft B and Byers' Creek the extensive open workings, Nos. 3 and 4, occasionally show on the faces a little tin ore, which seems to occur by preference among 'nests' of tourmaline, and on joints (which latter generally underlies south 45 degrees) in the neighbourhood of a fissure in the line of the lode worked in the levels in connection with Shafts A and B. The country rock here is granitic, but the biotite has mostly decomposed, and is frequently replaced by schorl.

"In the open workings, known as No. 1 Platform (near the southern boundary of Lease 26), a mass of tourmaline, varying from 2 in. to 5 ft. in thickness, furnished the great body of rich ore first obtained from the Lion's Den. It ran nearly north and south. Joint planes in the same line show crystals of cassiterite and tourmaline. No. 1 Tunnel, starting from this platform, runs south-east, and at 176 ft. cuts the lode AB at the 60-ft. level, 34 ft. north of Shaft B. From the point where the tunnel cuts the lode southward to Shaft A, the lode has been stoped out above the level. In consequence, I could see nothing of the lode except underfoot at its intersection by the tunnel, where I saw some good ore dug out from beneath the rails. Specimen 61 from this place gave, on assay, 10·78 per cent. of metallic tin.

" Along the level (= 60-ft. level of shaft A and B) north of its intersection by the tunnel for 20 ft., the lode is 4-ft. wide,

and has been worked out above the level. Twenty feet north of the tunnel a winze has been sunk 44 ft. deep; but owing to the accumulation of water I could not see the bottom, where the lode is said to be nearly a foot in thickness. At the northern face of the level the lode is pinched in hard ground to a mere joint plane. On this level the manager reports 'that nearly all the tinstone has been stoped out from the level to the surface, and that the quality of the stone has varied considerably, some very rich bunches having been opened up, while other patches have been of a less valuable nature, and portions very poor or altogether barren. Its richness varies from 2 to 3 per cent. to 20 per cent. oxide or even more. The width of the lode also varies considerably, sometimes running to a mere thread, and at other times opening out to 4 or 5 ft., but always retaining its character as a well-defined fissure lode.

"From 'No. 2 Platform' which is nearly on the same level as No. 1 and situated near the north-east corner of Lease 43, No. 2 tunnel has been driven to south 16 degrees west. At 260 ft. it cut the lode AB 77 ft. north 8 degrees west of Shaft A.

"The ore-dressing plant consists of:—A giant rock breaker, 9 in. by 15 in.; two sets of Walls's cyclone rolls, each 14 in. and 16 in., with automatic ore feeders; a revolving sizing trommel and automatic link-belt elevator, with buckets; two revolving trommels with screens; three sets of jigs; two Frue vanners.

"Little handling is required in the machine house, the working of the machinery being mainly automatic. The machinery is driven by a 6-ft. Pelton wheel, which is supplied by a flume from Byers' Creek 600 ft. in length, and an 11-in. iron pipe, 132 yards in length, with more than 200 ft. of fall. An extensive system of tramways has been prepared for conveying the ore from workings Nos. 1, 2, 3, and 4 to the mill.

"The 'surface' which is generally very shallow, has been stripped and washed in several places in the vicinity of the mines, while Jones's Creek from near Shaft B down to the machine has been entirely streamed for tin. Stream tin has also been obtained in large quantities higher up on the tableland.

"From an inspection of the manager's books I learned that from the beginning of June, 1889, to the end of May, 1890, 539 tons 3 cwt. 2 qr. of stone passed through the mill, yielding a total of 48 tons 16 cwt. 1 qr. 16½ lb. of 'black tin.'

"I received from the manager, Mr. Martin Carkeek, several specimens of white or nearly white cassiterite crystals from the alluvial workings in the vicinity of the mines and one of 'ruby' tin ore in the matrix, from the lode at the 60-ft. level."

Ross's Claim.—Worked on tribute by Wm. Sykes on the occasion of my visit in September, 1914; located on O'Keefe's Creek and Shanty Gully, distant 6 miles by rough track from Helenvale. About 8 ft. in thickness of alluvial rests here upon a thin bed of washdirt. The occurrence of tinstone here is stated to be somewhat patchy.

Jones's Claim.—Located near Ross's Claim, on the original claim known as the Madam Berry Claim, on O'Keefe's Creek. This claim was very rich in the early days of the field. The average depth of the overburden is 16 ft., resting upon a very soft granite and slate bottom; a little tin occurs through the overburden. There is usually an abundance of water for sluicing purposes. The tinstone is mostly rather coarse in grain with a tendency to be grey in colour; its occurrence is somewhat patchy. Neither gemstones nor wolfram have so far been met with, but odd "colours" of gold are obtained when washing up. Tin-bearing leaders are exposed at times in the granite bottom during sluicing operations. Tin assays 70 to 74 per cent.

A considerable quantity of recemented stanniferous washdirt occurring in the form of boulders have been crushed up for their tin contents. The slate bottom is frequently decomposed to the state of pipeclay. Ilmenite is met with in moderate quantity when cleaning up.

Close to the present working face a lode was opened on this claim by a trench to a depth of 10 ft.; the lode material is fine-grained kaolinised granite with tourmaline. About 4 tons of very coarse tin was obtained from here some years ago. Worked by David Jones, and is known as Jones's Tin Lode.

Plate 34 gives a view of the alluvial workings on this property.

McLean's Claim.—Situated on O'Keefe's Creek, a short distance downstream from Ross's and Jones's claims; owned and worked by Donald McLean. Operations are being carried on in the bed of the creek surrounded by dense vine scrub. The granite bottom is soft. The tinstone is partly waterworn and fine-grained. A moderate amount of black sand (mainly ilmenite) occurs with the tinstone, as also does a fair amount of tourmaline sand. The depth of alluvial averages about 4 ft., and tin in small quantity occurs from the surface downwards, the richer portion being close to the bottom. The gravel is composed largely of slate fragments. Rich surface tin was worked here some years ago along the left bank of the creek. The granite is very fine-grained and carries much tourmaline. Isolated small patches

of slate occur through the granite in this area. Approximately two ground sluice-heads of water were available at the time of my visit in October, 1914. The water is clear and is said to never fall below one sluice-head in quantity at any time of the year.

[*Photo.*, *W. Sykes.*

PLATE 34.—DAVID JONES'S ALLUVIAL CLAIM; IN SCRUB COUNTRY, O'KEEFE'S CREEK, TABLELAND.

About 3 chains downstream from McLean's workings occurs a very hard bar of granite over which the creek cascades for a total height of 100 ft. The rock forming this bar is of hard fine-grained acid granite containing numerous segregations of tourmaline. Numbers of small veins and round patches of quartzose material carrying tinstone and tourmaline have been opened to

a depth of a few feet along the bare rock face exposed here. Below the cascades the creek flows for the most part over bare rock. A little "surfacing" has been carried on in the scrub country adjoining the stream bed. The tinstone in this locality is very black in colour.

A prospector named Wm. Johnson was working an alluvial deposit along the creek about 4 chains downstream below the bottom of the cascades until recently, his work consisting mostly of the reworking of ground that had been worked for rich tin values in the early days of the field.

Several heavy "colours" of gold have been met with in this creek, resulting in all probability from the denudation of the adjacent slate areas. Tourmaline-bearing pegmatite veins occur here, especially near the slate-granite contact, which latter follows the creek bed very closely. The hard rock over which the creek here cascades is known locally under the name of the Fitzroy Bar. Segregations of tourmaline ranging up to 1 ft. in diameter occur as circular patches at times, surrounded by an aureole or outer ring of quartz 1 in. in width. Quartz veinlets traverse the granite in directions N20°W to N30°W, and also from E to E20°S, the latter series having been formed at a subsequent date to the former, as indicated by faulting.

Soiland's Claim.—Owned by Louis Soiland, and situated on the left bank of Mackie's Creek in dense scrub country. Operations are being carried on up the side of a rather steep ridge. The rock here is a partly decomposed fine-grained tourmaline granite and has been worked to a depth of 12 ft. A landslip has recently effaced the western edge of the workings. Water is obtained from Mackie's Creek by a race about 10 chains long. Numerous tourmaline leaders traverse the granite, sometimes carrying a little coarse tinstone. The owner hopes to install a pipe column for the next wet season sluicing period; he considers he has an average of one sluice-head of water available. It is intended to work up the ridge for a height of 100 ft. above Mackie's Creek. There will be a considerable amount of stone to be handled along the gully depression immediately above the present workings. A little tin occurs in the scrub country everywhere in this locality, but most of the payable deposits occur along the gullies, representing concentrated material. During the year he has been working here Soiland obtained 16 cwt. of tinstone. The tin is of very high grade and is mostly grey in colour; the grain size is medium to coarse. The bed of the creek hereabouts has been worked many years ago and is said to have been rich.

Bowditch's Lode.—Situated close to the left bank of O'Keefe's Creek, in dense scrub country between Jones's and McLean's Claims. Opened in the first instance in the year 1889 by Joseph Bowditch, and subsequently worked to a limited extent by George Anderson. The work done here consists of a round open cut about 10 ft. in diameter and 9 ft. in depth. The country rock is very hard fine-grained acid granite, containing tourmaline veins, seams and blebs. The tin occurred in a seam in the granite, the seam being practically flat with a very slight dip in a direction S20°E. The tin-leader has apparently been worked out, none now showing. Several bags of fine-grained grey tin were obtained. Not now being worked. I am informed by Mr. Bowditch that 11 tons of tin was obtained from the surface material covering 1 square chain surrounding this lode when it was first discovered.

Jones's Lode.—A quartzose lode in fine-grained acid granite was exposed in the tail-race at a spot 20 chains downstream from Jones's alluvial claim on O'Keefe's Creek. The width of the lode is up to 6 ft.; strike north and south; dip east. This lode shed very rich tin alongside itself at the creek; a little tin still shows through the quartz. Not now being worked.

White's Gully.—An upper right bank tributary of O'Keefe's Creek; worked by David Jones some years ago. The alluvial deposit here is of moderate width. The washdirt is composed largely of granite stones. The tin won here up to the present has been characterised by the number of nuggets met with. The alluvial averages 16 ft. in depth, but depths of up to 25 ft. have been reached. The bottom is extremely uneven. There is usually sufficient water for sluicing purposes obtainable from the gully itself. The occurrence of the tinstone here points strongly to the probability of its having been derived from neighbouring leaders in the granite close to the slate contact.

The head of the workings on this gully, at a point 400 yards upstream from the junction of O'Keefe's Creek, there is exposed a face of alluvial whose original depth was about 20 ft. to the bottom is granite. A nugget of tinstone weighing 28 lb. was obtained here some years ago, lying loosely on top of a quartz reef which runs through the granite in the centre of the gully; the strike of this reef is approximately north-west. Near the granite bedrock the washdirt here was cemented tightly together and necessitated the use of dynamite; the tinstone is coarse and black, and is usually rather waterworn. Several

shafts have been sunk still further upstream through the alluvial, the depth averaging 25 ft.; about 3 ft. of washdirt occurs here; the tin is limited to the washdirt.

McLean's Gully.—Heads close to the head of Lynch's Gully and joins Roseblade Gully on the left bank. Was worked some years ago by Donald McLean. The alluvial is 3 to 4 ft. in thickness, resting on a granite bottom. It was the intention of certain owners of the adjoining dredging claims to pump water from O'Keefe's Creek on to this gully from a point close to McLean's claim on that creek, as no water is available except during the rainy season. The tin values are stated to be fair.

New England Gully.—A depression along the left bank of Mackie's Creek close to the rock bar on the track to the "Look Out." Work was carried on here for a while by Donald McLean. The material sluiced was mainly poor grade shallow decomposed granite accompanied by much stone.

Austrian Gully.—Heads below the track from Mackie's Creek to Lynch's Gully and runs into Lynch's Gully on the right bank close to the junction of the latter gully with Mackie's Creek. This gully was much worked in the early days, and lately by Wm. Sykes. Depth of alluvial 4 to 5 ft., carrying a little shotty black tin all through. The tinstone is very patchy in occurrence and work is possible only in the wet season. No mining is now being carried on here.

Enchanted Gully.—A small tributary of Lynch's Gully situated a little closer to Mackie's Creek than Austrian Gully, which latter it resembles in every respect: lately worked by Wm. Johnson.

Lynch's Gully.—A left bank tributary of Mackie's Creek; it heads about 5 chains south of the Bower Bird lease and joins the main creek near Lion's Den. This area was previously worked by Jn. Lynch some twenty years ago, and is now worked mainly by Johnson at his claim situated about a quarter of a mile north of the "Look Out." The washdirt is up to 3 ft. in places, and carries coarse-grained tin of a rusty appearance due to a coating of iron oxide. This gully, which was rich in the early days, can only be sluiced during the rainy season. The overburden is of very shallow depth for the most part. Practically the whole course of this gully is through scrub country.

Roseblade Gully.—Heads close to Lynch's Gully and runs into Nolan's Gully on the Rossville fall of the range. This gully was worked with good results by Roseblade some twenty-five years ago, but no work is now being carried on here; of later

years it has been worked by McLean, Grant, and Johnson. The washdirt corresponds to the alluvial, tin being found from the surface downwards; average thickness, 4 ft. The bottom is granite; in fact the whole course of the gully is over that rock. The tinstone is of medium grain and black and rusty in colour. Water is available only during wet weather.

Red Gully.—An upper tributary of Trevethan Creek; it heads in the mountain known as Madam Berry. Small areas of the shallow alluvial have been worked along the stream bed by McMaster and also by J. Grant. The country here is all granite and is covered with dense vine scrub. Water is not available for sluicing except in the wet season. The tinstone is coarse to shotty in grain. Downstream this gully becomes extremely precipitous, and there must be nearly 1,000 ft. drop in a length of little over 1 mile.

Above the point where the gully becomes precipitous it is joined by a right bank tributary (unnamed) along which some work was done in the stream bed in the early days. This gully is also workable for tin in the wet season. Well marked cleavages characterise the granite hereabouts, the main direction being N20°W.

Shanty Gully.—Heads about half a mile south of O'Keefe's Creek, into which latter it empties close below Jones's camp. The ground is mostly shallow, and in the early days has been worked for rich tin values right from its junction with O'Keefe's Creek to its source. No work is at present being carried on except near its lower end.

Tramway Gully.—A right bank tributary of Slatey Creek, heading in The Gap on the mountain known as Madam Berry, and maintaining a general east and south-easterly course. This gully was worked to a considerable extent many years ago, but no mining is now being carried on here. Owing to its elevated position and the nearness of the alluvial deposits to its source there is an absence of sluicing water except during portion of the wet season. The alluvial is shallow (2 to 4 ft.) and rests upon a granite bottom. The tinstone won has been coarse and nuggety and of high assay value.

Work has in later years been carried on in the bed of the gully by Kastner, Ohlsen, and Gallagher. The washdirt is said to carry good tin values. In the early days of tin-mining here a small tramway was constructed for the purpose of conveying the washdirt to a neighbouring gully, in which latter is a spring of water, hence the name Tramway applied to it.

Maiden Gully.—A right bank tributary of Tramway Gully; this gully heads a short distance south-easterly of David Jones's claim on O'Keefe's Creek, and trends easterly to as far as The Gap, and joins Tramway Gully at a point approximately half-way down the eastern fall of the range. This gully is through granite country, and the washdirt, &c., is in every respect similar to that seen at Tramway Gully. No work is now being carried on, but a fair amount of mining was done here in former years by J. Finnessey and party, and later on by Wm. Sykes. Water for sluicing is available only during the wet season.

Lower Tableland.

The elevated area in the neighbourhood of, and drained by, Four-mile Gully, a right-bank tributary of Wallaby Creek, a mile and a-half north-west of Rossville and about 4 miles by track south-easterly of Helenvale, is known under the name of the Lower Tableland as distinct from the much more elevated area lying to the north-east on O'Keefe's Creek called The Tableland just described. The country rock is here entirely granite, the slate-granite contact extending along the western edge of the area in a northerly direction from near M.H.L. 17 to portion 42v on Mungumby Creek. Particularly along this marginal area the granite assumes a markedly fine-grained texture and is distinctly quartzose in character, resembling closely the "sandy" granites occurring in the Stanthorpe district,* but whereas in the latter case the rock has been clearly shown to belong to a different geological age than the normal granite which it intrudes, the fine-grained acid granite occurring along the periphery of the granite near the junction of the latter with the intruded slates at Lower Tableland is merely a variation from the usual type and is an integral part of the whole intrusive boss. Several small seams of slightly tin-bearing rock have been found along this marginal zone by Robert Henderson, but none have so far proved sufficiently encouraging to warrant opening up.

The country comprised under the name of the Lower Tableland is mostly of the open forest type. As indicating the Recent age of the alluvial here, mention should be made of the finding, in June, 1914, by Henderson of a blackfellow's stone tomahawk in the washdirt at a depth of 16 ft. below the surface level.

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* G.S.Q. Publication No. 243, p. 31 *et seq.*

Henderson's Claim.—Owned and worked by Robert Henderson. This claim is situated on Four-mile Creek at a point about a quarter of a mile upstream from the junction of that creek with Wallaby Creek, and about a mile and a-half west of Nolan's Gully. Water for ground sluicing is obtained from the main (or eastern) branch of Four-mile Creek and conveyed by race a quarter of a mile in length to the workings; two ground sluice-heads are usually available during the period January to August inclusive, the remainder of the year there being generally insufficient for requirements. At the time of my visit, in October, 1914, there were approximately one and a-half ground sluice-heads runnings. This claim had been worked to a small extent some years ago, but the present owner has been in the possession of the ground since about the year 1910, during which period he has unaided won some 5 tons of tin ore. The tinstone is of very high grade, averaging 75 per cent. in bulk parcels, but assays of up to 76 per cent. have been obtained, and many pieces of perfectly white tin can be seen in the bulk parcels of cleaned ore. It is mostly coarse grained and very little waterworn. Nuggets of tinstone up to half a pound in weight have been found, as also have a very occasional topaz. A little ilmenite and acicular tourmaline is usually present with the tinstone. The bottom is all of very soft granite and is inclined to "swell" for that reason when water runs over it for any length of time. The maximum width of the alluvial is about 200 yards, but only a fraction of this has been tested up to the present—namely, along the actual stream bed itself. A "fall" of about 40 ft. in a length of 100 yards occurs at the lower end of the claim, thus affording a good get-away for the material sluiced.

The owner estimates that the alluvial worked by him up to the present has averaged about 2 lb. of tinstone per cubic yard from surface to bedrock, but a good two-thirds of the total tin obtained was confined to the bottom 2 ft. No large stones have been met with in the washdirt so far, though undecomposed kernels of granite on the bottom at first sight look like granite boulders brought down by the stream. Well developed cleavage lines show through the hard granite over which the creek falls below the claim; the granite is coarse-grained. Average depth of alluvial is about 12 ft., the deposit consisting essentially of granitic sand and clay resting upon 1 ft. of gravelly washdirt. The tinstone occurs to a depth of 8 in. into the decomposed granite bedrock underneath the washdirt proper. Taking everything into consideration, this claim must be considered to be amongst the best of the "one-man" claims on the Annan Tinfield.

Delaplace's Claim.—On the northern branch of Four-mile Creek, adjoining Henderson's claim on the north (upstream) side. Worked by Delaplace, who is mining in an extensive flat along the left bank of the creek. The granite bottom is here very uneven and is mostly decomposed. The face showing at the time of my visit, in October, 1914, consisted of about 8 ft. of granitic sand and clay resting on about 18 in. of gravelly washdirt. The washstones consist in the main of quartz, which are usually quite angular. There is a much greater quantity of stone through the overburden here than is the case of Henderson's claim just described. The tinstone occurs along channels or runs in the washdirt and is not at all evenly distributed. Much of the surface hereabouts was worked in the early days, and a considerable quantity of tin is reputed to have been won. Nuggets of tinstone up to 15 lb. in weight have been found at times. The present owner has been working the property for a period of twelve years, during which time he has unaided won 9 tons of tinstone, assaying up to 76 per cent. Much of the tin found here is of the ruby and resin variety.

McLaughlin's Claims.—On the northern branch of Four-mile Creek, about a quarter of a mile in a direct line upstream from Delaplace's claim, Robert Henderson reopened an old alluvial claim in June, 1910, alongside the old Rossville to Trevethan track. About 2 tons in all of tinstone have been obtained from this opening since that date. The area has recently been worked by Arthur McLaughlin as opportunity offered, but it can only be efficiently worked during the wet season, as the claim is situated too close to the source of the creek to have sufficient water for sluicing throughout the year. The average depth of the alluvial here is 12 ft., the deepest portion being along the right bank of the creek, the left bank rising sharply on to a hard, bare, coarse granite bedrock. The tinstone is mostly coarse grained; it is of various colours and assays as high as 76 per cent. No ilmenite is met with but small quantities of tourmaline sand accompany the tin. Tin occurs from the surface down to bedrock. The bottom is mostly soft, with occasional hard bars.

At the source of Four-mile Creek, about 200 yards from the watershed separating it from the Mungumby Creek drainage area, a moderate amount of alluvial has been worked; the depth of overburden is here about 20 ft. and tin is stated to occur throughout this material. The alluvial consists of granitic sand with a little clay and rests upon a soft and very uneven granite bottom. The tin is similar in character to that found in the

claims downstream already mentioned. This upper portion of the creek has been moderately rich in places and is worked intermittently by McLaughlin as sluicing water is available.

Poulsen's Claim.—An alluvial claim close to the junction of slate and granite, on Poulsen's Creek, a right-bank tributary of Wallaby Creek, which latter it enters near portion 57v, at the edge of the scrub country extending from this point to beyond "The Forks" on the Annan River. The claim is situated about 1 mile up Poulsen's Creek from its junction with Wallaby Creek. Owned by S. Poulsen who commenced operations here about 1900 and has worked more or less continuously up to the present, during which period he has won about 12 tons of tinstone. The tinstone is of high assay value and comprises grey, white, amber, ruby, and black tin, assaying about 75 per cent. in bulk. The average depth of alluvial is about 15 ft., the tin values being limited to the bottom 2 ft. of gravelly washdirt. The bottom is mostly soft granite and very uneven. No gemstones have been seen here at any time. This claim can only be worked during wet seasons owing to the poor water supply; when seen by me in October, 1914, there was barely a quarter of a ground sluice-head available. Ilmenite occurs in irregular patches with the tinstone. The average width of workable alluvial is about 2 chains. The stones in the washdirt consist in the main of angular pieces of granitic quartz, aplite, and silicified slate.

About 10 chains below the claim the creek cascades over a hard bar of no great height composed of aplitic granite, and known as Poulsen's Falls.

Mount Leswell.

Mount Leswell Tin Lodes.—Messrs. Joseph Bell and Walter Colley; situated at Mount Leswell on M.L. 241 (10 acres).

Aneroid readings—Bell and Colley's hut—915 ft.; contact of the slate and granite on the track from Collingwood, 1,400 ft. (above sea level). Main working face, 1,180 ft.; Baird's Creek at Kidd's house, 550 ft.

A considerable amount of work has been carried out here in the past by various holders, the operations consisting of shaft-sinking and the driving of tunnels to test the numerous large tourmaline lodes through the granite. A short distance in from the mouth of the main tunnel, at the end of the crosscut, a large mass of tourmaline has been exposed; its strike is apparently north-east south-west, and it is accompanied by about 18 in. of quartz; the tourmaline formation exhibits here a westerly

inclination, but this dip is probably an apparent one only, as it may well represent merely the side of a rounded lense. No tinstone was showing in this formation at the time of my visit in November, 1914, but it is accompanied by numerous thin flat seams of reddish-brown clay, which latter material has been found from past experience here to usually accompany tin values. At the point along the tunnel where No. 4 shaft is cut, a leader of tourmaline about 18 in. in width has been followed down the shaft from the surface, tin having been found on the exposed outcrop and also showing sparsely in the tourmaline down the shaft; the lode strikes about north and south and underlays east at a slight angle. This tourmaline leader approaches the level of the tunnel on the western side of the latter; it is accompanied by about 15 in. of highly quartzose granite, and diminishes in places to 6 in. in thickness. At the winze from the end of the eastern tunnel the tourmaline band assumes a width of 4 ft., and is joined by another large tourmaline lode followed down in the winze. The granite "country" at the junction of these two lodes is much more kaolinised than elsewhere. This winze is a continuation of shaft No. 3; about 10 ft. along the tunnel from the winze practically the whole of the tunnel is through tourmaline with some kaolinised granite, which latter produces a mottled appearance locally considered to be favourable for the existence of "makes" of tin ore. At the end of the tunnel, which is in decomposed granite containing irregular isolated patches of tourmaline, is some broken ground which connects through to the No. 2 shaft, in which latter patches of good ore were obtained from a tourmaline-quartz lode. The lode here dips west of north. This portion of the workings is now too unsafe for inspection. At the winze from the eastern tunnel the strike of the tourmaline lode is E10°N and the dip northerly at a steep angle. Along the level at the top of the winze at the south end the tourmaline belt occupies the whole of the drive. Other drives from this tunnel appear to be all through granite "country." At the tunnel entrance a large tourmaline-quartz blow is exposed; this latter formation outcrops along the surface immediately above the tunnel mouth. About 30 ft. S20°W of No. 4 shaft a large blow of tourmaline with some quartz was opened at the surface in an open cut, and corresponds with the tourmaline lode met with at the end of the crosscut from the tunnel at the bottom of No. 4 shaft referred to previously. Tinstone is showing through the lode material on the dump at the No. 4 shaft. Good values are also said to have been obtained from the material raised from No. 2 shaft.

No. 1 shaft, which is situated 58 links away in an east-north-east direction, has apparently been sunk through country rock, but was in all probability connected underground with the main tunnel near that part of the latter at No. 2 shaft where the heavy creep has subsequently occurred. The south shaft was sunk on a large blow of tourmaline carrying good tin values; it is said that 100 tons of tinstone was obtained from these workings in the past, the original miners being Davis and party, about eighteen years ago; also tributed during the Leswell Company's previous ownership by W. Davy for a payable return. The main open cut workings are situated near the shafts high up on the steep hillside. At the end of the tunnel connecting through to the south shaft a large body of tourmaline with numerous red "floors" of clayey material has been exposed and opened out by a drive in a north-westerly direction along the formation; the ends of the lenses of tourmaline usually gradually merge into a more quartzose material, the quartz being glassy in appearance. A considerable quantity of tourmaline occurs at the end of the crosscut connecting the south tunnel from the open cut to the south shaft. Tourmaline continues down the shaft to the bottom from here (about 20 ft.). Some 10 chains west of the main open cut workings, down the ridge, a tunnel was commenced in granite by Rogers a few years ago, but this prospector died before attaining the object in which he was engaged—namely, the interception of these lodes at a depth. It is understood that the tunnel in question was carried in for 300 ft. in granite. Rich "surfacing" has been obtained from on top of and also below the lode outcrop. The tourmaline occurs mainly in the form of radiating bunches, and it also exhibits a radiating structure when seen in the quartz veins accompanying the large blows. At the time of my examination several thin seams of nearly pure tinstone in the tourmaline blow were being bagged by Messrs. Bell and Colley. The "makes" of tin here are at right angles to the run of the reddish-coloured cracks through the lode. The open cut workings are on the largest quantity of tourmaline hitherto exposed anywhere on the property. The method at present in vogue for extracting the tinstone is hand-picking of the ore, followed by roasting to render the material readily broken up, then crushing by means of a spring dolly, followed by jigging. I am informed by the owners that the tinstone sold by them has averaged 73·4 per cent.; a sample of the concentrates obtained by jigging was submitted for assay, and the Government Analyst gave an assay return on this material of 68·1 per cent. of metallic tin.

Several nuggets of tinstone have been found in the alluvial material down the hillside, which latter it is intended to sluice when a sufficient quantity of water is available.

Taking this property as a whole I am of opinion that it is best suited to working by two or three miners, who should closely study the occurrence of the rich tin leaders through the tourmaline formation and limit their operations to extracting same rather than to attempt to work the whole formation.

Mount Harbord Tin Lode.—Situated on the right bank of Mount Leswell Creek, downstream from the Mount Leswell leases. It was discovered in 1889 by William Davy, and a syndicate was subsequently formed which worked the claim for upwards of a year. The lode occurs in slate country (chloritic greywacke—R. L. Jack) at a point about a chain from the slate-granite contact. The lode formation runs approximately north and south and underlays easterly. Several shafts were sunk at intervals along the strike of the lode, and also a main shaft sunk vertically to a depth of 70 ft. The lode at the surface is distant 15 ft. from the main shaft; a crosscut was put in at the 30-ft. level, and the lode met with in a distance of 10 ft. from the shaft, and found to be 3 ft. thick. The shaft was then continued vertically to the bottom. A crosscut from the 60-ft. level intercepted the lode at about 5 ft. from the shaft, the width of 3 ft. seen at the 30-ft. level being still maintained; a little tin was showing on the hanging-wall in both these crosscuts. A tunnel was subsequently driven along the strike of the lode from a point lower down the hillside for a distance of between 50 and 60 ft., and from this working-place some 16 cwt. of tinstone was dollied out, the tinstone being obtained from a small "bunch" located towards the end of the tunnel. No work has since been carried out on this property, and as the whole of the workings are quite inaccessible the major portion of the above notes are not my own observation, but were kindly furnished by Mr. Joseph Bowditch, of Rossville, who is well acquainted with the operations carried on here in the early days of Mount Leswell mining.

Wheal Davey.—This lode, not now working, was seen by Dr. Jack, then Government Geologist, about the year 1890, when he reported as follows*:—

"The Wheal Davey Mine is comprised in Lease 58, to the south-east of Mount Leswell, and on the same spur, but probably

* Tin Mines near Cooktown: Second Report; 1891, p. 3 (now out of print). G.S.Q. Publication No. 66.

at an altitude lower by about 500 ft. The country rock is soft granite, similar to that of Mount Leswell. The cap of the lode can be seen down the hill about 1 chain south of the eastern shaft. It shows large masses of quartz, and also of coarse-grained tourmaline, crystals of cassiterite being frequently visible on joints and faces. Two shafts have been sunk, about 20 ft. apart, on an east and west line, both about 40 ft. in depth, and connected by a level near the bottom. In the eastern shaft, near the bottom, I could see a large lode underlying to the west at a low angle."

Kelso's Claim.—Owned and worked by Daniel Kelso; situated at the head of a gully which is a right-bank tributary of Mount Leswell Creek. Operations were commenced in June, 1906. The alluvial material treated here is mainly of shallow depth, the greatest thickness seen up to the time of my visit being 10 ft. A little tinstone occurs throughout the overburden. The bottom rock is fine-grained granite with some tourmaline. Water for sluicing is obtained from Spring Gully at a point some 700 yards north of the working face. The tinstone is mostly sub-angular, black and red, and partly crystallised; bulk parcels are stated to assay from 73 to 75 per cent. Kelso is also doing a little work at *Red Hill Claim*; this claim was originally worked some years back for rich tin values. The depth of ground is in this case about 6 ft. of which the lower 4 ft. is the tin-bearing wash-dirt. Much stone, fortunately of "forking" size, occurs in the washdirt. Several nuggets of tin up to 1 lb. in weight have been obtained; the tinstone is mostly of the coarse variety and distinctly reddish in colour. The bottom rock consists of slate. Water for sluicing at this claim (Red Hill) is obtained from a small gully distant 400 yards north of the workings; a sufficient quantity for sluicing requirements is stated to be available for eight months in the year. No very great area of stanniferous alluvial has so far been proved to exist here, but there is probably a moderate area of payable ground yet to be worked in an upstream direction.

Mount Tolbert Lode.—Situated on the cap of a high, steep ridge running south-south-easterly from the peak of Mount Tolbert towards Mount Leswell ridge. An excellent view of the surrounding tin country, particularly of the Rossville, Home Rule, and The Tableland area, is obtainable from this elevated spot. A large tourmaline-quartz lode occurs here, occupying the absolute contact zone between the slate and the intruding granite. A shaft, now inaccessible, was sunk about the year 1888 to a

depth stated to be 60 ft., but judging from the still remaining spoil dump at the mouth of the shaft, it was probably much deeper. The rock is good mining ground. No water is obtainable on this ridge for the treatment of the tin-bearing material.

Fair alluvial tin is said to occur along the hillsides hereabouts, especially in a north-westerly direction towards Saddler's Gap. The shaft was apparently sunk with the object of meeting the tourmaline lode at a depth. The lode is somewhat obscured by soil, but it appears to be in granite though the shaft has been sunk in slate. The lode is about 12 ft. in width where exposed, but no tin appears to have been definitely found in it. I am informed that this claim was last worked by Michael O'Shea, now residing in Cooktown.

Recompense Claim.—Owned by Messrs. Edward Saunders and George Downe; situated near the Chain Bridge at Mount Leswell adjoining the Grasstree road, about 1 mile south of Baird's Creek crossing. Operations were commenced in 1907. Water for sluicing is at present obtained from Baird's Creek by a race 1½ miles long, but an efficient supply is usually obtained for six months in the twelve, the pressure at present available being only 25 ft. Work was formerly carried on below the road, where an average depth of ground of 3 ft. was met with; the alluvium here contains numerous boulders of quartz-tourmaline rock closely resembling those seen on Mount Leswell, and rests upon a slate bottom of very uneven surface, rendering the operation of "cleaning-up" much more tedious than is usually the case on this field. The tinstone is partly waterworn and is accompanied by a limited amount of black sand. Odd "colours" of gold are obtained, the largest recorded weighing ¼ dwt. and being very waterworn. The tin values have so far been somewhat patchy in occurrence.

Recently work has been carried out along the top side of the Grasstree road, where ground similar to that seen on the lower side already mentioned has been worked.

It is intended to bring in a race from Banana Creek, 2½ miles in length, with 900 ft. of pipes, yielding a pressure of 40 to 50 ft., in order to sluice an older alluvial deposit on the top of the adjoining flat-topped hill; this latter hill is covered with a thin sheet of basalt, and shallow shafts sunk through that formation have established the existence of a bed of washdirt of apparently some extent and stated to carry payable tin values. It is highly probable that the Recent alluvial deposits worked

here in the depressions immediately below this rising ground have derived their tin in large part from the denudation of this older basalt-covered bed of washdirt. The owners estimate the yield of the wash met with here up to the present at 2 lb. of tinstone per cubic yard. The dip of the washdirt suggests that the deepest ground will be ultimately found to occupy the central portion of the basalt-covered area, which would here correspond to the summit of the hill. The tinstone assays 72 to 73 per cent.; that obtained from the top of the hill is much finer-grained on the average than that won from the recent alluvials below the ridge.

Should they finally bring into existence the new race they have in mind to carry water from Banana Creek, a water supply of seven months duration in the twelve is expected. The old race from Baird's Creek at present in use is through soft slate country for a considerable portion of its length, and hence there is a great loss from soakage.

Mount Hartley and Sand Hills.

Mount Hartley workings are situated about 7 miles by track from Rossville; a second track in a north-easterly direction crosses Slatey Creek and meets the Cooktown road *viâ* Mount Amos. Along Mount Hartley Creek and also its right-bank branch known as Cameron's Creek, the contact between the slate and granite is clearly visible and proves beyond doubt the intrusive character of the granite. The contact of these formations is well shown at a spot a few chains up from the bottom of the Bonnie Dundee (Graham's) tail race where the slate has been silicified and hardened into a very resistant bluish quartzite and is traversed by abundant ramifying quartzose seams and veinlets. The accompanying drawing (approximately to scale) will give an idea of the occurrence (figure C).

The latter portion of the journey from Rossville to the Mount Hartley workings is up a very long steep hill covered with dense vine scrub; hence the landing of machinery, stores, &c., must always be a costly item. At the time of my visit there were a total number of five miners at work in this portion of the district, there being experienced considerable difficulty in persuading workmen to stay owing to the isolated location of the field and the consequently high charges for the packing out of stores from Cooktown.

As compared to Rossville district the rainfall at Mount Hartley shows much wetter conditions to have existed during 1914 than at the former locality, the figures kindly furnished

to me by the courtesy of Mr. P. S. Graham showing Mount Hartley as having had a total of 221 in. up to 3rd December, whilst the Rossville returns show a total of 128·92 in. to the end of the year. During 1913 and 1912 the figures for the Mount Hartley rainfall was 119 and 181 in. respectively.

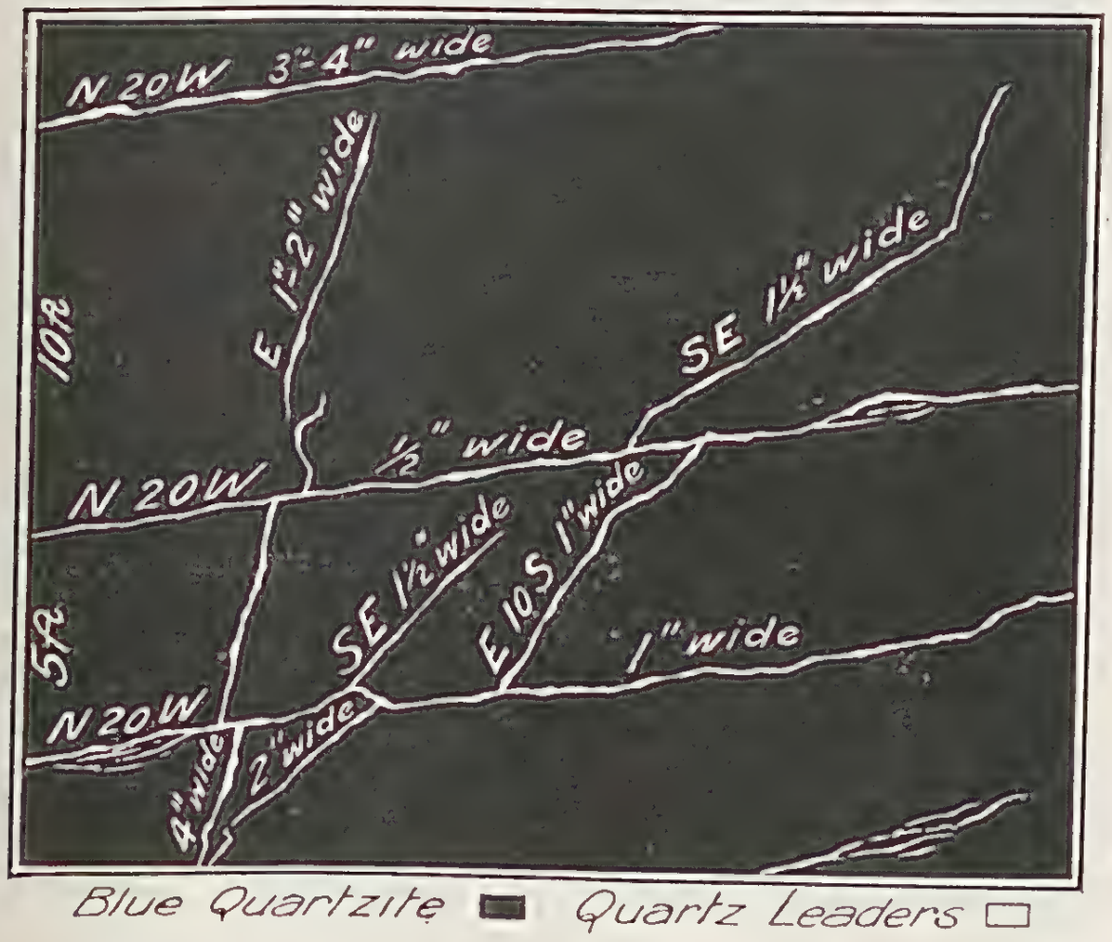


Fig. C.—Veinlets of Quartz traversing Quartzite.
Close to slate-granite contact, Bonnie Dundee Claim, Mount Hartley.

The accompanying aneroid readings as taken by me may prove of interest, particularly as regards the possibility of raising water from Mount Hartley Creek to the Sand Hills property referred to below:—Rossville, 500 ft.; track close to Simpson's old hut, 1,940 ft.; Symons' hut, 1,800 ft.; top of suggested pumping site on Graham's claim, Mount Hartley Creek, 1,745 ft.; Graham's old hut, 1,700 ft.; face at the Sand Hills property, 2,050 ft.; top pumping-station for Sand Hills, 1,945 ft.; Hughes's Look Out, 2,120 ft.; main dam in Darby's Gully, 1,855 ft.

Great quantities of passion fruit of excellent size and flavour are growing wild in the scrubs around Mount Hartley Creek,

and show the extreme suitability of the soil and conditions for the production of that crop; pineapples and lemons also thrive excellently, though quite untended.

The returns furnished to the Mines Department by the Warden at Cooktown give the following yields from Mount Hartley for the five-year period 1910-1914, inclusive:—

	Tons	cwt.	qr.	lb.	Value. £	s.	d.
1910	15	1	0	8	1,437	5	0
1911	8	19	2	9	998	10	0
1912	2	14	3	0	336	15	0
1913	1	2	0	0	127	0	0
1914	6	11	3	8	676	0	0
Total ..	34	9	0	25	£3,575	10	0

Just-in-Time Claim (W. J. Symons).—At the head of a small right bank tributary of Cameron's Creek, close to the slate-granite contact. The granite is mainly aplitic in character, with blebs of tourmaline, and carries numerous veins and horizontal seams of tourmaline. The tinstone appears to be fairly evenly distributed through the decomposed granite constituting the material being sluiced. Numerous fairly rich leaders carrying tin have been exposed to depths of as much as 50 ft. in the granite; strike north, dip vertical. The granite is much kaolinised for an average width of 3 in. on either side of these leaders, and this kaolinic material is frequently highly stanniferous and in general appearance resembles the kaolin occurring at the old Collingwood lode.

With the water pressure available at the time of my examination of this portion of the field in the early part of December, 1914, the decomposed granite can be readily sluiced to a depth of approximately 30 ft. from the surface, but it has been found, up to the present, that the upper 20 ft. carries the best tin values. An open cut some 5 chains in length and three-quarters of a chain in width has been sluiced out in order to test the ground in bulk, and I am informed by the owner that the whole of the material treated from the cutting has averaged a shade over 2 lb. of tinstone per cubic yard. Water for sluicing is taken from Mount Hartley Creek at a point 1½ miles distant from the claim by means of an earth-cut race, the quantity usually available in the wet season being one ground sluice-head; the inefficient supply available during the drier portion of the year does not allow of this property being sluiced, except during the rainy season. With the race and pipe column at present in use the available water pressure is estimated by the owner to

be about 80 ft. During the wet season, an average of two and a-half men (including the owner) are engaged here, the wages paid to efficient miners being 13s. per diem.

The tinstone is of medium grain and the average assay value of bulk parcels is given as 72·3 per cent., though, of course, individual assays up to as much as 75 per cent. have been obtained. A moderate percentage of the granite here consists of stone too little decomposed to allow of being reduced to a state of sand with the pressure available, but no very large boulders have been encountered hitherto. Neither gold nor gemstones have been noticed with the tin. The present owner has been working here for about twelve months, during which time payable results appear to have been obtained by him. Several small circular patches of fine-grained clayey material carrying rich tin values have been found through the face. No explosives have been necessary up to the time of my visit. The ground here has been fairly well prospected by means of shallow shafts alongside the open cut, and is stated to have indicated the existence of a payable deposit so far. The surface of the ground is inclined to be bouldery, but this structure does not persist in depth.

On the cap of the ridge just immediately ahead of the face exposed in December, 1914, a service dam was constructed some time ago, and the soil and decomposed granite excavated therefrom is stated by the owner to have yielded as high as 4 lb. of tinstone per cubic yard. Prospecting up to the present indicates that the best tin values follow closely to the slate-granite contact. A borehole, 39 ft. in depth, stated to average 3½ lb. of tinstone per cubic yard, was put down at a point 3 chains ahead of the present face.

Coarse tinstone can be readily seen at intervals in the surface soil along the track through the scrub towards *Anderson's* old claim. A shaft sunk many years ago to a depth of 25 ft. by previous owners of the ground, at a spot close above the track, is reputed to have recovered lumps of tin up to 60 lb. in weight; and Symons assures me that his sampling of this shaft from top to bottom gave an average yield of 4 lb. per yard.

A moderate amount of work was also carried out some years ago along a quartz-tourmaline leader striking N35°W, and I am informed locally a block of ground was at that time taken up under the name of the *Black Prince Claim,* by Messrs. Finnegan and Wright. I was told by the owner that a consider-

able amount of boring to a reported depth of 27 ft. was carried out over his property a year or so ago, under the direction of Mr. Horton, representing Southern capitalists, but the assay plan showing the results obtained from about sixty bores then sunk was not available.

Whilst admitting the existence of coarse tin scattered through the surface soil, I am not in a position to verify the high values quoted in the aforegoing, and am strongly of opinion that intending investors should assure themselves of the values by independent sampling, and also ascertain if a more efficient water supply could not be obtained than that at present available.

Dr. Jack (late Government Geologist) visited Mount Hartley about 1890, and his notes concerning mines then working are of interest. He says:—"The rock met with on the ascent of Mount Hartley was a granite with very large crystals of orthoclase felspar. In rock of this character is the 'No. 1 opening,' 10 ft. deep, on the *Black Prince* line of lode. The lode runs north 35 degrees west, and is vertical and about 2 ft. 6 in. in width, of which width one-half is 'horse.' A heap of stone taken from this opening consists of quartz, tourmaline, and arsenical pyrites, with crystals of cassiterite, sometimes of unusually large size. The lode appears to die out to the north, and increase in size to the south. The granite in the neighbourhood of the lode for some distance on both sides contains crystals of tourmaline.

"About a quarter of a mile up the spur to the south a second opening (*Wright's Lease* No. 99), about 20 ft. long by 4 ft. wide, has been made in the same line, on a vertical joint running north and south through granite country. The granite in the neighbourhood is talcose and ferruginous. The stone raised shows decomposed arsenical pyrites in a talcose matrix with occasional cassiterite crystals.

"In the same lease, rather less than a quarter of a mile further up-hill (south), a shaft has been sunk to a depth of 42 ft. on a lode, the cap of which has been exposed in a number of open cuttings extending for about 54 ft. to south 10 degrees east. I did not go down the shaft, as I was informed that it contained foul air. A few tons of stone at the top showed quartz, tourmaline, and arsenical pyrites. The open cuttings average about 10 ft. in depth (excluding surface wash), and show the lode to vary from 6 in. at the south end to 3 ft. at the north end, and to go down vertically through a country rock of cross-grained decomposing granite. One heap of picked stone,

about 8 by 5 by 1½ ft., showed quartz, felspar, tourmaline, arsenical pyrites, and a little tin ore. The tin ore is of better quality than it appears at first sight. One sample, when crushed and panned off, turned out to be about half tin ore, although its specific gravity and a small quantity of visible cassiterite were the only indications of its richness.

"About half a mile south of the Black Prince is the *Caledonia Claim*. The intervening country rock, as seen in a race cut for the supply of water to alluvial diggings, is chiefly greywacke. Near the north end of the claim an opening has been made about 15 ft. long and 15 ft. deep, in a fine-grained rock consisting of silica, felspar, and hornblende—apparently a dyke—varying from 18 to 30 in. in width, traversing decomposed slate and greywacke country from north-west to south-east. Down hill to the east about 2 chains, and within the same claim, are some openings extending east 20 degrees south (down hill) for nearly 2 chains, on a dyke of fine-grained matted talc and felspar, varying to felspar and hornblende. The dyke varies up to 3 ft. in width. Some stones from the open cutting show a thickness of 6 in. of the talcose rock, fairly rich in tin. I saw fragments from a vein at least ½-in. thick of nearly pure tin ore. Eight hundredweight of similar ore are said to have been sent away. At the lower end of the open cutting is a shaft 40 ft. deep, which, however, is in an unsafe condition. At the surface the dyke is 4 ft. in thickness, and as far as can be seen from the top it first thins and then thickens. On the hanging-wall side there was a rich leader which some specimens on the top showed to have been about 2 in. thick, the remainder having been comparatively poor. A tunnel is being driven from the north towards this shaft, and it is estimated that it will cut the dyke at a depth of 200 ft., besides prospecting the ridge for further deposits of ore." Further reference to this lode is made on page 123.

Bright Smile Claim.—Owned by W. J. Symons; adjoins the Just-in-Time claim along the northern boundary. In the southern portion of this claim, close to the track, several rich leaders traversing granite have been worked to a shallow depth; the strike of these leaders is northerly. Several shallow shafts have been sunk on the leaders, the country rock being mainly a very fine-grained quartzose granite. This area was originally worked by James Hennessey over eighteen years ago. No work was in progress at the time of my visit. A small gully, known as Simpson's Gully, running north-westerly into Asimus Creek, which latter is a left-bank tributary of Slatey Creek, has been worked over during recent years; this gully lies prac-

tically along the slate-granite contact. The average depth of the alluvial is about 6 ft., but it appears to be deepening as the gully is ascended. The bottom rock is of hard bouldery granite. The alluvium consists of stony (slate and granite) material containing coarse tinstone.

A considerable area of payable ground is reputed to occur along the sides of the ridges adjoining the gully channel. Specimens of tinstone up to 42 lb. weight and assaying 72 per cent. metallic tin have been found here. Good tin values have been obtained from around the edges of small "islands" of slate in the granite. The values, however, taken as a whole over the area worked here, have been found to occur in more or less definite runs. Moderately good tin was found in the shallow surfacing around Simpson's old hut (shown on Map No. 2), but the comparative hardness of the granite bedrock, which itself also carries small values, is decidedly against easy sluicing.

At a point about 1 chain easterly of the north-eastern corner of the Bright Smile claim a granite dyke intruding slate country has been opened up to allow of the extraction of a contained reef of sugary quartz 1 ft. wide carrying tinstone in association with tourmaline and a little sericite. This lode was opened many years ago by a trench 15 ft. long and 10 ft. deep. The strike of the intrusion is north and south. Leaching has gone on in the ore body to a moderate extent and there are indications of the presence of arsenical minerals.

In *Picket Gully,* about 130 yards west of Symons' Just-in-Time claim cutting, a lump of tinstone weighing 1½ cwt. is reported to have been found by a miner named Dillon some years ago.

Black Peter's Gully.—This gully heads close to the open cut on the Just-in-Time claim and runs into Mount Hartley Creek. It proved to be very rich in the early days of the field. The depth of the alluvium is about 12 ft., the material consisting of stony wash resting on a granite bottom, the latter rock intruding slate along the eastern side of the stream. Very many large nuggets of grey tin were found here by the early miners, but no work is at present being carried on, and the only mining that appears to have been done latterly was the working a small area by Symons at the head of the gully.

Harvest Home Claim.—Owned and worked by Louis Roberts; situated on Cameron's Creek, adjoining the Just-in-Time property downstream. At the time of my visit Roberts

was working out some patches of alluvial that early miners had left along the bed and the right bank of the creek.

A considerable area of alluvial still remains along the left bank. The deposit is very uneven in both thickness and character, but the average material consists of about 6 ft. of very stony washdirt comprising fair-sized boulders of slate and granite. The creek follows approximately along the slate-granite contact in places, the actual bed of the stream being usually granite traversed by numerous leaders of quartz and tourmaline. Slate occupies the country along the left bank of the stream. No gold or gemstones have been recorded here hitherto. Water for sluicing purposes is obtained from both Cameron's Creek and also a small quantity from Lumbuck Springs, which latter are situated some 16 chains above the intake from Cameron's Creek on the left bank of that creek. There is usually a sufficient supply to enable sluicing to be carired on efficiently for about eight months in the year. The tinstone consists mainly of coarse angular grains showing crystal outlines, and assaying from 69 to 74 per cent., but averaging 72 per cent. in bulk parcels. Very many tin nuggets and lumps of granite and quartz with masses of tinstone entangled have been found on this ground at various times. The present owner has been working here for the past couple of years and his intention is to work along the left bank alluvial during the coming rainy season. The bottom rock is extremely decomposed at times, particularly on the lower portion of the claim, but upstream it is harder and very uneven.

Bonnie Dundee Claim.—Owned and worked by P. S. Graham; situated on Mount Hartley Creek near the junction of Cameron's Creek and adjoining Louis Roberts's Harvest Home claim downstream. In 1913 a 10 horse-power Crossley oil engine was installed, as also were a 20-ft. bucket elevator fitted with 32 buckets, and a 3-in. centrifugal pump, at an estimated total cost of £250. The average depth of the ground is about 5 ft., but faces of alluvial up to 10 ft. in thickness are exposed. Operations by the present owner were commenced here about five years ago, when a sum, stated to be £500, was expended in blasting a tail race out of quartzite and driving a short tunnel through the same formation, a bar of very hard rock some 500 ft. across being shot out to a depth of 5 ft.

The washdirt is very stony and consists essentially of river shingle. The best tin values through the deposit are disposed along the bottom wash and following the main stream channel, but payable values may be obtained at times from the banks.

Taking the claim as a whole, the distribution of the tin values must be classed as patchy. The bottom is very bumpy and several very deep potholes have already been exposed during sluicing operations. An area some 12 chains in length by 5 chains in width has been worked in part by the present owner. Mount Hartley Creek hereabouts was very rich in places during the early days of the field. It is of interest to record the fact that whereas the tinstone along the right bank of the creek and also along its right-bank tributaries—*e.g.*, Cameron's Creek—is decidedly coarse-grained, that along the left bank is of much finer grain. A quantity of "specimen" tin was obtained from the upstream portion of the claim. The quantity of tinstone reported to me by the owner as having been won to date is somewhere in the neighbourhood of 40 tons.

A considerable area has been sluiced to a shallow depth in the scrub country along the left bank of Mount Hartley Creek. The alluvial deposit here rests on a shallow slate bottom and is said to be fairly rich, prospects of 1 lb. to the dish being reported. Quite an appreciable amount of tinstone studded in the decomposed slate bottom was showing at the time of my visit. Two men were then engaged at work on this property, but Mr. Graham informs me that as many as twenty miners have been employed on this property on some occasions, particularly during the blasting out of the tail race. A rich tin leader has been worked here at the slate-granite contact. During the rainy season work cannot be carried on along the stream bed, and hence during those months water is brought from a left-hand branch of the main creek by means of a race 850 yards in length, which yields a gravitational supply sufficient to enable the higher ground in the scrub country off the left bank to be treated. It has been found that no very great difficulty is encountered from the thick vegetation of the scrub, as it readily topples over into the already worked out areas when the soil surrounding the tree roots is removed by sluicing. The tinstone along the left bank (terrace) is mainly located along the bottom.

A fairly extensive area of ground still remains to be worked on this property along the main stream channel, the flats adjoining the channel, and also in the scrub land along the stream edge. Tin in payable quantity is stated to have been obtained from the material removed during the sluicing out for a small service dam in the scrub country above the shallow left-bank workings on slate country referred to previously. It is estimated that about 40 ft. of pressure was available from this service dam during the last rainy season. A dam of considerable

capacity has been formed in the main creek and water is pumped on to the left-bank workings during the dry weather, thus ensuring a supply throughout the year. Above this main dam exists a flat of about 40 acres which boring is reported to have indicated would be payable ground with suitable appliances. From the results obtained to date by actual mining, as well as from extensive prospecting and boring, the tin values may be said to run in several more or less parallel narrow leads. Owing to the flatness of the ground and the absence of an efficient get-away for the tailings without additional heavy expenditure in blasting a much deeper tail race, I am of opinion that the best mode of working this ground would be by means of a dredging plant of the light portable variety, but before such expenditure was undertaken it would, of course, be necessary to thoroughly sample the property by means of a large number of boreholes and also to ascertain the cost of transporting machinery and stores to this locality, as also the wages that would need to be paid to miners to encourage them to remain in this somewhat isolated area. At the lower end of the claim some 7 tons of tin were obtained by Graham, whilst 8 tons was also previously won by Dillon along the right bank of the creek close to the small patch of forest country in the scrub known as The Pocket.

In the bed of Mount Hartley Creek, below the Top Falls, some 45 tons of tinstone were obtained from a relatively small area in the early days by Louis Soilands, the alluvial deposit here consisting largely of large quartz boulders shed from the outcrop of that rock on the adjoining scrub-covered ridge along the left bank.

Italian Gully.—This gully is a right bank tributary of Mount Hartley Creek, which latter it joins at the lower end of Graham's claim. It proved to be so rich in the early days that the washdirt was trucked by a party of Italian miners along a small tramline to Mount Hartley Creek for treatment. The alluvial is of shallow depth and rests upon a hard granite bottom close to the slate contact. In December, 1914, an Italian named Formasini was doing a little mining there.

Nolan's Gully.—A left bank tributary of Mount Hartley Creek in dense scrub country; heads near the Sand Hills and joins the main creek below the Top Falls; the alluvial has been worked for half a mile in length along the gully by P. Nolan and others, and is stated to have yielded payable returns. Water for sluicing is available only during rainy weather.

Sand Hills Claim.—The Sand Hills Syndicate's property is located on M.L. 221, situated about 1 mile to the south-west of Mount Hartley on the summit and along the north-eastern fall of the Sand Hills Ridge. The area is covered by dense vine scrub, which latter has been partly cleared from around the main open cut workings. Tin is stated to have been worked here about eighteen years ago by a prospector named Sparks (?), and subsequently by John Hughes and others; the property afterwards passed into the possession of the Sand Hills Syndicate (Messrs. Davies-Griffith, Sloan, Higgins, and Marsh), and was later, I am locally informed, controlled by Messrs. Marsh, Cleary, Nevins, and Griffiths. The syndicate commenced operations between two and three years ago.

Three small dams were constructed at the head of Darby's Gully for the purpose of supplying sluicing water. In order to raise the water from these dams up to the open cut on the top of the ridge two benzine motors operating two 4-in. centrifugal pumps were installed, but the plant appears to have proved of too low capacity to supply an efficient stream of water.

Only an insignificant amount of tin was won before operations ceased, and no work has been done here for the past twelve months. The material treated consists of a deposit of white granite detritus, from 2 to 12 ft. in thickness, resting upon a highly decomposed granite containing broken quartz leaders, some of which carry tin, as also does the granite itself. Leaders of tourmaline striking north and south also traverse the granite. The total area sluiced here at the top of the ridge is represented by the open cut, which is 3½ chains in length and 1½ chains in width and 30 ft. in maximum depth. At the bottom of the cut boreholes were put down a further 24 ft., and are stated to have yielded tin in payable quantity. Several good yields of tin have been obtained by various parties on the occasion of heavy rains, when it is found that water oozes freely up through the highly decomposed granite forming the present bottom of the cut. It is estimated that an area 5 chains in width and several chains in length, running in a north-south direction, is available for sluicing.

There has been a suggestion put forward at one time to construct two large dams on Graham's Bonnie Dundee Claim on Mount Hartley Creek, and pump a supply up the approximately 300 ft. (vertical) height between the two claims named. Along the ridge below the main face a number of prospecting shafts have been put down, and all appear to have passed through decomposed granite, stated to carry fair values.

Rumours concerning attempted "salting" of the deposit during the time it was being sampled are locally credited with having driven capital away from this proposition. The sampling of this property at the present time would be an extremely easy matter, in view of the numerous shallow shafts that are all readily accessible. A *picked sample* of tinstone from this claim (assayed for Messrs. Lempriere) gave the extraordinary yield of 77·4 per cent. metallic tin.

Darby's Gully or Darby's Nest.—Heads at the Sand Hills and joins Mount Hartley Creek about half a mile below the Bonnie Dundee Claim. This gully has been worked intermittently from the early days right up to quite recently. The wash-dirt is stony and rests on a decomposed granite bottom. The tin is mostly waterworn and assays up to 75 per cent. This gully has been recently worked by McAuliffe and Bannan at a point some chains below the main supply dam of the Sand Hills Syndicate. Along the right bank the bottom is very uneven, and consists of soft granite overlain by a great quantity of large granite and porphyry boulders.

Caledonian Tin Lode.—Situated near the head of the right-hand branch of Mount Hartley Creek on a ridge above the right bank of the creek, and lying to the left of the track from Mount Hartley workings to Cedar Bay. No work has been carried on here for some time, and in consequence thereof the workings were not in a sufficiently safe state to permit of a proper examination being made by me of the lode. The tin ore occurs here in a dyke of bluish aplitic greisenised granite intruding slate country in a, roughly, north-west direction. The lode has been followed along in the early days with a tunnel for a short distance, and then opened up by means of a winze sunk to a depth reported as being 20 ft. This lode has been reworked in previous years by Bannan and party, and also by Messrs. Morgan and McLaren. Specimen tin has been obtained, but the major portion won latterly appears to have been fine-grained cassiterite. It is said that during the sinking of the winze the lode yielded about half a bag of tin per foot sunk, and that on following the ore body down a crosscourse was met with on which the ore cut out rapidly in the form of a wedge-shaped block of tinstone weighing 3½ lb. and assaying 72 per cent. of metallic tin. A shaft sunk to a depth of 70 ft. from the surface meets the tunnel at the winze. The course of the dyke is stated to have been traced at intervals through the dense scrub country for a distance of 600 yards over the hill; tin in small quantities is reputed to have been found in odd pieces of this granitic rock along the strike. I was informed by Mr. Joseph Bowditch

that at a point 20 ft. down the shaft a "floor" occurred, throwing the lode a few feet out of the shaft, but it was again picked up by continuing sinking; and that there appears to be a slight underlay to the east.

Slatey and Granite Creeks.

Slatey Creek is an important right (north) bank tributary of Wallaby Creek, which latter stream it joins near the eastern corner of M.L. 143, about 2 miles east-south-east of the village of Rossville. The stream heads in the high country close to Cedar Bay and flows westerly for some miles across slate country to near the edge of the main granite mass, at which point it is joined by a right-hand bank tributary known as Bunks Creek; in Slatey Creek, immediately upstream from the junction of Bunks Creek, Slatey Creek tumbles over a cascade known as the Bunks Falls, the bedrock in the creek being hard slate. From the Bunks Falls, Slatey Creek flows practically due south to its confluence with Wallaby Creek, a distance of about 2 miles. At a point slightly on the Bunks Falls side, midway on the eastern boundary of M.L. 232, the stream leaps over a hard slate precipice known as Home Rule Falls, and it is from the top of these falls that the Home Rule Company take their water by pipe-line on to their workings. (*See* under "Rossville:—New Queensland Tin Sluicing Company," page 49.)

For practically its total length this stream, as also its main left-bank tributary, Granite Creek, flows through dense vine scrub. The water is beautifully cool and clear. There can be little doubt but that, if the excellent Bloomfield River supply for Lode Hill be excepted, this creek constitutes the best water right in the area examined by me, both as regards its elevation and the volume of water available. Alluvial tin-mining has been carried on for years along this stream, and also along its right-bank tributaries, viz.:—Bunks Creek and Sinclair's Gully, as also along its main left-bank tributary, Granite Creek.

Slatey Creek Prospecting Claim.—Situated on a small left bank tributary of Slatey Creek, about 11 miles by rough track through dense scrub from the village of Rossville. No work was in progress at the time of my visit, and I was informed locally that nothing had been done for some months previous to my visit in January, 1915. The owners are stated to be John White and party. The depth of the ground varies from 5 to 15 ft.; this alluvial material, which contains numerous large boulders of granite, rests upon an unusually soft granite bedrock. In the early days of the field this claim was extremely rich, and a very

considerable tonnage of tin was won, old miners claiming as much as 100 tons as the output. The tinstone is medium in grain and black. Several rich tin-bearing leaders of short length are reported to have been found at various times traversing the granite floor. An efficient supply of water for sluicing can be reckoned on here during the wetter portion of the year only.

Nuggety Claim.—Owned by David Woodes; situated on Slatey Creek, a short distance from the Slatey Creek prospecting claim just described. The average depth of the ground is about 7 ft., varying from 5 to 10 ft. The bedrock consists of slate and is overlain by very numerous boulders of the same formation. This area is too flat to allow of proper "fall" being obtained without entailing an expenditure out of all proportion to the results that may reasonably be looked for. The tinstone is black, and is medium-grained; assays 70 to 72 per cent. Woodes was, in January, 1915, working on a small flat along the left bank of the creek close to his hut. There is an abundance of water throughout the year, and in the wet season work has to be suspended owing to the area becoming flooded out. About half an acre has been worked by the owner since he commenced sluicing about five years ago; during that period his average earnings have been 15 cwt. of tinstone per annum, which must, of course, be considered as poor. No tin-bearing leaders have hitherto been exposed in the bedrock. The overburden consists of a fine sandy loam resting upon about 3 ft. of washdirt, the essential tin values being found in the latter. In consequence of the bad road to this portion of the district and the paucity of miners engaged there, the charges for packing are £7 per ton from Cooktown, and even at that high rate a sufficient quantity of stores has to be ordered to induce the packers to make the trip.

Holmes's Claim.—Owner, Frederick Holmes. This claim is situated on Sinclair's Gully, a right bank tributary of Slatey Creek, which latter it falls into at a point about 1½ miles above the junction of Slatey Creek and 1 mile above the Cooktown track. The tinstone is medium to coarse grained and angular. In the early days nuggets up to 10 lb. in weight were often obtained. The average depth of alluvial is approximately 7 ft., but the tinstone appears to be limited to the washdirt solely. At the time of my examination, in January, 1915, work was being carried on along the bed of the gully. This area was previously worked for about seven years by D. Woodes. The washdirt is very stony and numerous large boulders are met with. There is usually about eight months' sluicing water available. The bottom is slate—mostly partly decomposed.

Owing to the close proximity of the intrusive granite much of the slate has been indurated with the production of rock much resembling ordinary basalt at first sight. A typical specimen of this rock can be examined at the Geological Survey Museum collection. The tinstone assays from 72 to 74 per cent. Odd "colours" of gold are found at times when cleaning up the boxes. Unfortunately the ground on this claim is now practically worked out, the alluvial having been removed from along the creek bed to a point upstream where the gully is crossed by a hard rock bar. Taken generally the values obtained here latterly have not been of sufficiently remunerative a nature to warrant a continuance of mining.

The packing charges to this portion of the field are necessarily high—£7 per ton—mainly by reason of the rough track from Rossville along which supplies have to be brought.

Belgium Claim.—Owned by J. J. Eldridge; situated on the left bank of Granite Creek, about 10 miles by track (mainly through dense vine scrub) from the village of Rossville. Water is conducted on to the ground along a head race a quarter of a mile in length starting from a dam on Granite Creek and skirting the left bank of the creek; several small tributary gullies that previously emptied into the main creek downstream from the dam are intercepted by the race, small dams having been constructed at these depressions, at which points the gullies add their quota to the amount of water available. Altogether this claim may be said to be well provided with water for sluicing purposes, but the lack of "fall" operates disadvantageously. It was found absolutely necessary to construct the main dam in Granite Creek in order to raise water to a sufficient height to allow of it entering the head race. The tinstone is mostly coarse in grain and distinctly angular, and has probably not travelled any very great distance downstream to its present position. The owner is at present working along the fringe of a small "bump" of slate, apparently quite surrounded by the intruding granite. Two men were employed at the time of my visit in January, 1915.

Downstream below the working face the creek makes an extremely rapid descent to the valley below, but unfortunately for ease in working the undoubtedly extensive alluvial deposits occurring upstream it would be difficult to shoot a tail race through the heap of giant boulders down crevices between which the stream finds its way. Several attempts have at various times been made to blast a tail race at this point, and former owners—

Grant and party—actually shot to a shallow depth through for a distance of 67 ft. the bar of hard granite immediately upstream from the boulders just referred to.

Judging from the appearance of the face there are indications that somewhat deeper ground will be met with along the left bank of the creek adjoining Eldridge's present (January, 1915) working place. Tin is stated to occur in payable quantity from the surface to the bedrock; 27 cwt. of tin have lately been taken from the small area worked up to the time of my visit. The claim is situated in very dense scrub. Huge granite boulders occur through the overburden and at times have been temporarily mistaken for the true bottom. A little gold—negligible from an economic point of view—is frequently obtained during sluicing operations; H. Russell obtained 2 dwt. of the precious metal some time ago from a claim close by.

As stated above the absence of "fall" in the creek hereabouts and for a very considerable distance upstream therefrom renders it practically impossible to treat for tin the large area said to be payable without either the construction of a very long head race or having to resort to pumping. In the case of the construction of a long head race it must be remembered that such a race would necessarily tap the creek at some point so far upstream that it would not receive the water from the many tributary gullies which join the stream between that point and the point at which it is desired the water for sluicing is to be applied. The only reasonable method of working would therefore appear to entail the blasting of a deep race through the hard bar which has undoubtedly dammed back the stream and caused the deposition of the extensive alluvial deposit upstream. A large amount of tin was obtained from a shallow depth in the area lying between this bar and Eldridge's present face, but as soon as creek level was passed the amount of water encountered effectually precluded much further progress being made by hand methods. Even then, I am informed locally, a considerable amount of tin was won by the miners standing in the water and blind-stabbing the washdirt underfoot.

McAdam's Claim.—At Top Camp, on Granite Creek, 2 miles upstream from the Belgium claim. Owing to the fact that this claim is outside the area mapped by me and insufficient time was available at the time of my visit to Granite Creek to inspect this holding, the following particulars were kindly supplied to me by Mr. J. J. Eldridge, who had previously worked there. Slate bottom; ironstone wash. Coarse angular tin, assaying 71·3 per cent. The present owner is working on a terrace deposit some

20 ft. above the creek level. About 2½ ft. in thickness of washdirt is exposed, the washdirt being stated to be moderately rich. Unfortunately only an extremely limited quantity of water is usually available for sluicing.

Below this claim, and between it and the Belgium claim, the creek is remarkably level, rendering it a difficult problem to obtain the "fall" requisite to work the ground by the ordinary sluicing methods.

Mount Amos and Phœnician.

This is an elevated portion of the field, situated in the north-eastern section of the area mapped, and not far distant from the coast at Mount Amos Bay. Mount Amos itself is a high, scrub-covered peak (2,800 ft.), situated to the north-west of the lode workings on the Phœnician property.

Dykes of a bluish green felspar porphyry intrude the slate country on the ridge along the steep track to the Phœnician.

It is usually found here that where the tinstone occurs in a quartz matrix it is very fine-grained, but when found in tourmaline it assumes a much coarser structure. The most favourable situation appears to be near the walls of the lode formations between felspar and tourmaline, a "bung" of rich ore being frequently discovered under these conditions. With regard to the occurrence of the mineral in tourmaline, reference will be seen in the accompanying notes on the Phœnician Lode.

The area is drained mainly by Waterfall Creek, and its chief (left-bank) tributary, Royce's Creek. The contact of the slate and granite closely follows the latter stream, granite occupying the western (Mount Amos) side, whilst slate is found from the eastern side of the creek right down to the coast. The contact of the slate and granite country may be also seen at the site of the old battery, the line of junction between these two formations swinging round to the main tunnel.

A deep gorge exists along Waterfall Creek near to its entrance to the sea.

With regard to the very numerous lodes occurring in the region, I consider that they are unsuited for companies, but that they would frequently repay small parties of working miners who would limit themselves to prospecting either for new lodes or else searching along the strike of the already opened ones for new shoots of ore; there appears to be no reason whatever why the pay shoots should not occur just as frequently *along* these

lodes as in depth, and as the matter of sinking shafts in hard granite is always costly and the finding of pay shoots decidedly fortuitous, I am strongly of opinion that lode mining in this locality should be carried out on the lines indicated. None of the lodes seen by me could be classified under any heading other than that known to miners as "working-men shows."

Molybdenite, wolfram, native copper, bismuth carbonate, and mispickel are reported to have been found in small quantities on the Phœnician property, but none was seen by me; the ore from that mine, I am informed, was once penalised up to as high as £4 per ton owing to the presence of sulphur, &c.

For the Five-Year Period ending 31st December, 1914, Mr. Warden Power records the following Outputs from Mount Amos and Phœnician.

Locality.	1910.							1911.						
	T.	C.	Q.	L.	£	s.	d.	T.	C.	Q.	L.	£	s.	d.
Mount Amos—alluvial ...	22	10	0	25	2,173	0	0	11	1	0	10	1,209	3	0
,, lode	...				...			...				...		
Phœnician—lode	4	3	2	16	322	17	9	6	8	0	0	691	0	0
Total	26	13	3	13	2,495	17	9	17	9	0	10	1,900	3	0

Locality.	1912.							1913.						
	T.	C.	Q.	L.	£	s.	d.	T.	C.	Q.	L.	£	s.	d.
Mount Amos—alluvial ...	18	8	0	4	2,374	5	10	20	18	3	16	2,670	2	9
,, lode... ...	...				...			...				...		
Phœnician—lode	16	14	0	21	2,117	13	0	1	10	1	17	176	3	0
Total	35	2	0	25	4,491	18	10	22	9	1	5	2,846	5	9

Locality.	1914.						
	T.	C	Q.	L.	£	s.	d.
Mount Amos—alluvial ...	9	0	2	11	943	6	6
,, lode	7	0	3	9	592	19	0
Phœnician—lode	1	14	0	0	166	0	0
Total	17	15	1	20	1,702	5	6

Archibold's Claim.—A considerable area has in the past been sluiced by P. Archibold and Sons immediately in front of the old (Archibold's) hotel at Mount Amos, a few chains back from the left bank of Mount Amos Creek. The average depth of the ground is about 9 ft., but depths of 22 ft. were reached at times. A bumpy cemented band of pipeclay and conglomerate was

PLATE 35. FALLS CREEK, MOUNT AMOS.

considered for practical mining purposes as being the "bottom," but the true bedrock is most probably slate. Water for sluicing purposes was obtained from Mount Amos Creek by a race 1 mile in length; the supply was frequently insufficient for effective sluicing. The tinstone obtained was mostly of the coarse black variety and partly waterworn. The average assay value of parcels in bulk for the first sixteen years during which the claim was worked was 72 per cent., but subsequent parcels returned

75 per cent. No work has been done here during 1914, but prior to that year an area of, roughly, 1 acre had been treated.

This area carried a great number of quartz boulders, some of which carried rich tin. Occasional specks of gold have been seen with the tin, but no gemstones have so far been noted. Much fine-grained quartzose tourmaline granite as also tourmaline occurs as boulders through the washdirt. The deep ground is located on the Mount Amos side of the workings.

Better Luck Claim, owned by Messrs. Bernard J. Walk and Wm. Hassett, and situated along the ridge above the left bank of Waterfall Creek, about 1 mile from the coast. The depth of the alluvial averages 30 ft., the overburden consisting of clayey material containing boulders of granite, many of the latter being now much decomposed, as in the case of those seen at the Home Rule property near Rossville. Several boulders of hard granite have been met lying along the bedrock. The tinstone is fine-grained. The bottom is of decomposed slate and very uneven. About two sluice heads of water was available at the time of my visit in December, 1914, but an efficient supply of sluicing water is obtainable for only about eight months in the year. The water is obtained from Gibson's Creek and Stockyard Creek. In consequence of the relative tightness of the overburden it is frequently found necessary to use explosives. It is intended by the owners to later on work towards the north-eastern corner of the workings as the best tin values have been found to occur in that section. From an area of, roughly, a quarter of an acre about 3 tons of tinstone had been won to the date of my examination. There can be no doubt but that the alluvial deposit being worked at present on this claim was laid down at some period in geological history preceding the typical Recent alluvials found along existing stream channels.

Forest Devil Claim, owned by Messrs. Geo. and Fred. Norris, situated between Royce's Creek and Waterfall Creek, above the old Phœnician Machinery Area (M.A. 18). The average depth of ground worked has been about 15 ft., the deepest portion being towards Royce's Creek. Work is carried on here during the wet season only, when a total of four men are engaged; during the three years this claim has been worked an area of 1 acre has been sluiced with the nozzle. Water is obtained from Royce's Creek by a race a quarter of a mile in length, and also by a second race from Waterfall Creek half a mile long. The bottom is rather bumpy and consists of decomposed slate. A little tin occurs all through the overburden, but the best values

are found along the bottom. The overburden is somewhat cemented in character and contains a quantity of granite boulders throughout. The tinstone is coarse and angular, and usually grey in colour; assays 71 to 72 per cent. in bulk, about 8 tons having been won up to the end of 1914. A considerable area (at least 350 yards in length) of ground considered by the owners to carry payable values exists up the ridge in the direction of Mount Amos. The best tin values recorded to date appear to be located along the southern edge of the workings.

Phœnician Lode, owned, I am informed, by the Mount Amos Tin Mining Company, and being worked at the time of my visit by the Messrs. Vallis Brothers, situated on M.L. 217.

A tunnel was driven in for about 70 ft. in order to intercept a tourmaline lode outcropping on the surface. No tin appears to have been met with along the lode except at two points, one on the northern end of the workings and the second towards the southern end. The strike of the lode is north and south; underlay slightly west. In the southern end a winze 35 ft. deep was sunk on an ore shoot, and from this section of the mine some 8 tons of tin are stated to have been obtained. A cross lode, striking N. 20 degrees E., was also followed along here for a few feet, the ore met with being mainly confined to the intersection of this lode with the main body. At the end of the drive along the cross lode the latter still occupies at least the full 6 ft. of the face, but the tin values have apparently practically vanished. The values are also stated to have disappeared at the bottom of the winze in hard white quartzose granite. No tin has been traceable above the level. Owing to the amount of water encountered in these workings a small (3½ h.p.) oil engine had to be installed.

The Messrs. Vallis inform me that their observations up to the present cause them to consider that the presence of much fine-grained bluish coloured tourmaline is the best indicator of good tin values in the lode, little or no tinstone occurring with the coarsely crystallised radiating masses of tourmaline.

In the north winze (30 ft. deep) the body of ore worked measured 30 ft. in length at the bottom of the winze and yielded 30 tons of tin ore. A cross leader was met with here likewise. The strike of the master-joints in the granite hereabouts is south-west north-east. An air shaft 25 ft. deep connects from the outcrop to the north winze and showed a little tin in places down itself. A few feet south of this shaft a shallow cut has

been put in along a quartz-tourmaline lode which joins the main lode and has undoubtedly produced the tin at the north winze. The tin values cut out at a depth of 6 ft. in this trench.

Close to the western side of the main Phœnician lode a parallel lode of similar nature has been opened. The tin occurs here in a pipe-like lens about 20 ft. in width. The values disappeared at a comparatively shallow depth. Three additional "bungs" of ore were met with along the strike in a south direction. Towards the southern end of the lode very rich tin was obtained in the form of nuggets lying along the upper surface of the ore-body. A quantity of arsenical pyrites has been found to exist with the ore on this claim, whilst copper is stated to be always shown as present in the assays.

Mr. Lionel C. Ball, B.E., Assistant Government Geologist, in reporting upon this area on 9th February, 1908, in connection with an application for assistance (papers Mines 993 Geol. Survey) stated:—" The lease is located on the contact of granite and slate, where, the abundant crops of quartz-tourmaline rock indicate, pneumatolysis has been active and where one would naturally expect to find tin-ore. Unfortunately, however, the ore occurs not in well-defined lodes but near the intersections of joints in the granite, when locally altered to greisen, or to tourmaline-quartz rock, generally in the form of pipes, as on the Walsh and Tinaroo. Quite a number of isolated bodies have been tested here by shafts and tunnels, the richest and largest of them being that in the south drive from the main adit.

" The main adit at 70 ft. from the face of the hill struck a body of ore, which has been driven on for 50 ft. to the north and 50 ft. to the south, there being a winze full of water and of unknown depth, 15 ft. from the southern end.

" At the winze, from which, it is stated, 30 tons of ore containing 10 per cent. tin was taken, the lode is 12 in. wide and gradually increases to a maximum of 7 ft. just to the north of the adit, beyond which point it gradually decreases again to 2 ft. 6 in. in the northern face. A sample (185) was taken from the lode by chipping across it in six places—the average width being 3 ft. 6 in. The result of the analysis (Government Analyst) is:—

Tin = 0·6 per cent.,

showing the ore on this level to be unpayable on the whole."

An aerial haulage way (No. 6 wire) 300 ft. in length connects the top workings on this property with the main tunnel.

Phœnician South Extended Claim.—Adjoining the boundary of this claim a shaft has been sunk in extremely soft kaolinised granite for about 35 ft. in depth, but was abandoned owing to unexpectedly meeting with old workings below ground. The granite itself here contains insignificant amounts of very fine-grained tinstone.

Collins's Claim.—Nothing has been done on this block (M.L. 225) during recent years other than "surfacing."

Tourmaline Claim.—Owned and worked by George Norris. This claim adjoins the southern boundary of one of the Phœnician blocks (M.L. 225). The strike of the lode is north and south and the underlay slightly west. Operations were commenced here during 1914, the upper surface being sluiced off and a shaft then sunk to a depth (December, 1914) of 20 ft. At the top of the shaft the lode is about 5 ft. in width, the footwall (eastern) side being 18 in. of quartz, whilst the centre consists of massive tourmaline, with tourmalinised granite on the hanging-wall. The tin has been mainly located in the central portion of the lode up to the present. At the bottom of the shaft the ore-body is about 7 ft. in total width. The tinstone is contained in short ore lenses and is mostly brown in colour; the grain size is coarse in the central portion, with fine tin scattered sparsely through the quartzose portion. A little over 2 tons of tin have been obtained, the stone being crushed with a bucking hammer. Cross lodes are met with here in close proximity to the best tin values. Two men are engaged on this claim.

Dreadnought Claim belongs to the Mount Amos Tin Mining Syndicate; on M.L. 230 (10 acres). At 5-head stamper battery, with Wilfley table, card table, buddle, and classifier, operated by a 12-h.p. engine have now been erected to treat the ore from the lode. The tunnel which is situated higher up the ridge is connected to the battery by a short aerial ropeway (¾ in.), prior to the installation of which the ore was carted down a steep dray track cut out of the hillside. Water for battery requirements is obtained from Royce's Creek.

A tunnel 100 ft. in length has been driven along the lode in a direction S.10°E. and shows the lode to consist in the main of semi-transparent quartz with some tourmaline in a quartzose tourmaline granite. The width of the lode matter varies greatly, being very narrow at the face in the end of the tunnel when seen by me in December, 1914. At a point about 15 ft. in from the tunnel mouth a shoot of moderately good ore has been found and followed for 3 ft. below the level of the tunnel; this shoot is stated to have been also met with on

the surface outcrop of the lode immediately above the tunnel. Elsewhere, however, the lode does not appear to have carried useful values. At the time of my visit the lode was being worked by a tributer. There is a slight westerly underlay observable. Fairly good values are reputed to exist in the lode underneath the tramline in front of the tunnel entrance.

A large tourmaline quartz lode formation occurs close to the western side of the tunnel and appears to be running in a direction N.20°E. and should meet the main Dreadnought lode in front of the tunnel. Ten bags of tinstone were obtained from this formation by Norris and party, and it is quite possible that good values will be found at the junction of these two formations. An old shaft about 54 ft. in depth has been sunk at the southern end of the Dreadnought lode, the latter being found to underlay sharply to the west and to carry tin all the way down. The end of the tunnel is now close up to this shaft, and it is estimated that when the position of the shaft overhead is reached there will be then some 40 ft. of backs available.

Several very large quartz tourmaline granite lodes occur on this property, one noteworthy lode being situated close to the eastern side of the shaft referred to in the aforegoing.

Mr. Warden Power's report for 1914 states as follows:—"The battery after a short trial required correction, and some difficulty was experienced in getting fuel and stone carried to the mill. Towards the middle of the year a new manager (Mr. Jones) was appointed. He has made some alterations to the battery, such as installing an automatic feeder for the stone and erecting a buddle. Some 100 tons of stone, most of which came from the Dreadnought lease, was put through for a yield of a little over 2 tons of tin, valued at £198. This tin was penalised on account of containing sulphur. Preparations have been made to make an early start in the new year. There are some 30 tons of stone from the Dreadnought at grass ready for the mill. It is intended to open this lease and properly develop it."

Norris's Lode.—Situated just outside the eastern boundary of M.L. 230 in slate country close to the contact of the latter with the intruding granite. Strike north and south; dip vertical for 30 ft. then underlays slightly to the east for a further 24 ft. The tinstone was grey and pink in colour. At the bottom of the shaft granite was met with when the lode rapidly narrowed to a small size and water made its appearance. About 3 tons 8 cwt. of tinstone was obtained. About 30 lb. weight of white slime tin, much resembling chalk, was obtained from a depth of 40 ft. in the shaft. A seam of soft fine-grained micaceous

tourmalinised granite traversed the lode at right angles and the best tin was obtained from this portion. The shoot of tin pitched to the south. The slate on which the tin was found has been highly silicified and is now in reality more of a chert than a silicified slate. This claim has not been worked for the past five years, the interesting particulars quoted above having been partly furnished to me by Mr. Norris, jun.

A considerable area of shallow "surfacing" has been worked in the past on the slope of the ridge between this lode and the Dreadnought battery; the bottom rock is here slate. "Surfacing" has also been worked close to the track to the battery just beyond the northern boundary of M.A. 20.

Three Mile.

Hurricane Gully Claim.—This claim is located beyond the northern boundary of the area included in the geological map accompanying this bulletin, owned and worked by Messrs. Henry Russell and Sons, situated on Hurricane Gully, a left-bank tributary of Trevethan Creek, 3 miles on the Trevethan side of Mount Amos. The average depth of the alluvial at the face exposed on the occasion of my visit to this portion of the field in December 1914, may be set down as 15 ft. Below the washdirt exists an even-floored cemented granitic material which probably rests on granite, but no true bedrock was exposed at the time of my examination of the property. A little fine tinstone exists from the surface downwards; by far the best values are found in the lowermost 3 ft., but the distribution of the tin in the latter is frequently patchy. The stones in the washdirt consist essentially of granitic quartz and tourmaline of small size with occasional large boulders of granite. At least 2 acres of ground has been sluiced, and from this block about 20 tons of tinstone have been obtained. The tinstone is medium-grained and vari-coloured; assays from 72 to 75 per cent. in bulk.

Water for sluicing is obtained from the Falls Creek (a left-hand tributary of Trevethan Creek) and conveyed to the workings by a race 3 miles in length, including fifteen flumes of from 50 to 100 ft. each in length, made of 20-gauge flat iron and measuring 16 in. in width and 10 in. in depth. The highest flume is 25 ft. above the creek it crosses. There is usually an abundance of water available for about eight months in the year. The ground is sluiced with a nozzle. At the lower end of the area sluiced 120 ft. of pressure was available, but only 70 ft. can be obtained on the higher ground.

The owners expect that owing to the depth of the alluvium

at the northern end an elevator will be required. It is intended in the immediate future to work in an upstream direction. Three sapphires and a few specks of gold have been obtained from the area already treated. A considerable area of alluvium occurs to the west of the present workings, but this has not yet been thoroughly tested as regards tin values, though there can be little doubt but that the payable values occurring all along the face on that side will be found to be very extensive. In addition to the owner, a total of eight men are employed during the rainy season on this property and the neighbouring Davison's Gully claim belonging to him; three shifts are usually worked, but only two for the past season. Explosives are occasionally required to loosen the overburden, notably along the western face, dynamite being employed for the purpose. Operations have been conducted here for the past nine years, but the nozzle has been in use for only a couple of years.

Davison's Gully Claim, also owned by Henry Russell, situated near Davison's Gully; this gully is a right-hand branch of Hurricane Gully, which latter it joins just below the Hurricane Gully Claim. The average depth of the alluvial here is about 8 ft., the overburden consisting in great part of stone. Tin occurs right from the surface, but the best values are found towards the bottom. About ¾ acre of ground has been worked here, for a yield of 3½ tons of tinstone. Numerous large boulders of quartz-porphyry occur on the decomposed granite bottom. A nozzle has been installed here during 1914. Between this claim and Davison's Gully a considerable area has been worked by hand in the early days of the field for highly payable results. It is intended to work along the southern face next season. Much of the alluvium is very tightly cemented.

Not only have Mr. Russell's two claims described above been highly payable in the past but there also still remains many years of profitable work ahead of them. For the year 1914 these claims gave a yield of 11 tons of tinstone from 9,000 cubic yards treated, but none except that portion of the output disposed of in the early part of the year has been sold, owing to the low price ruling for tin.

Grasstree and Jackeroo.

Grasstree is the name applied to an elevated area (1,100 ft. above sea level) lying to the south-west of Mount Finlayson, along the left bank of the Annan River and its tributary, Grasstree Creek. There is a small settlement here comprised of the various families owning the alluvial claims. The whole of the

country hereabouts is granite. The distance of this place from Cooktown is 37 miles, the last portion of the journey being decidedly rough and mountainous, and often necessitates the steadying of vehicles by fastening trees on behind when negotiating one or other of the steep gradients occurring between Helenvale and Grasstree (distance apart 16 miles). Between Grasstree and the foot of the range towards the Bloomfield River the track is through dense vine scrub to the top of Stuckey's Gap (distant 4½ miles from Grasstree) at an altitude of 1,250 ft. above sea level.

The Warden's returns, showing the output of tinstone for the five-year period ending 31st December, 1914, are as follows:—

	Tons	cwt.	qr.	lb.	Value. £	s.	d.
1910	13	12	2	12	1,337	11	6
1911	12	15	0	27	1,485	19	0
1912	3	0	1	3	397	11	0
1913	12	2	1	26	1,718	10	0
1914	0	8	0	0	40	0	0
Total ..	41	18	2	12	£4,979	11	6

Judging from the above returns, however, it appears as though a good proportion of the returns from Grasstree are included in the figures quoted for the adjoining Mount Romeo district.

Grasstree United Claim, owned by Messrs Daniel Bolen and George Bathe, consists of three amalgamated claims, of a total area of 30 acres, located on Grasstree Creek, a left-bank tributary of the Annan River. Work is now being carried on towards the head of this creek. The bottom on which the alluvium rests is of soft kaolinised granite and presents an extremely uneven surface, much of the washdirt lying in depressions along the bottom, which closely resembles the "melon-hole" or "devil-devil" country of Western Queensland. The tinstone occurs in rich seams through the bottom washdirt. Relatively, very little stone is met with in the tailings. In places the tinstone occurs right from the surface downwards, but by far the best returns are obtained from along the bottom. The average yield of the whole of the material sluiced is from 3 to 4 lb.; the last paddock treated gave a return of 5 tons 17 cwt. of tinstone from 3,700 cubic yards treated.

Water is obtained from the Annan River from Bolen's Dam on that river at a point named Bolen's Falls, about 1 mile from the claim, and is conveyed thence by 20 chains of wooden fluming and a mile of pipes (11½-in. diameter) to the face, the pressure obtained at the present working site

being estimated at 75 ft. at the elevator and 60 ft. at the nozzle. During the rainy season of the year an average rainfall of 90 in. is recorded; an abundance of water is always available except during a very dry season.

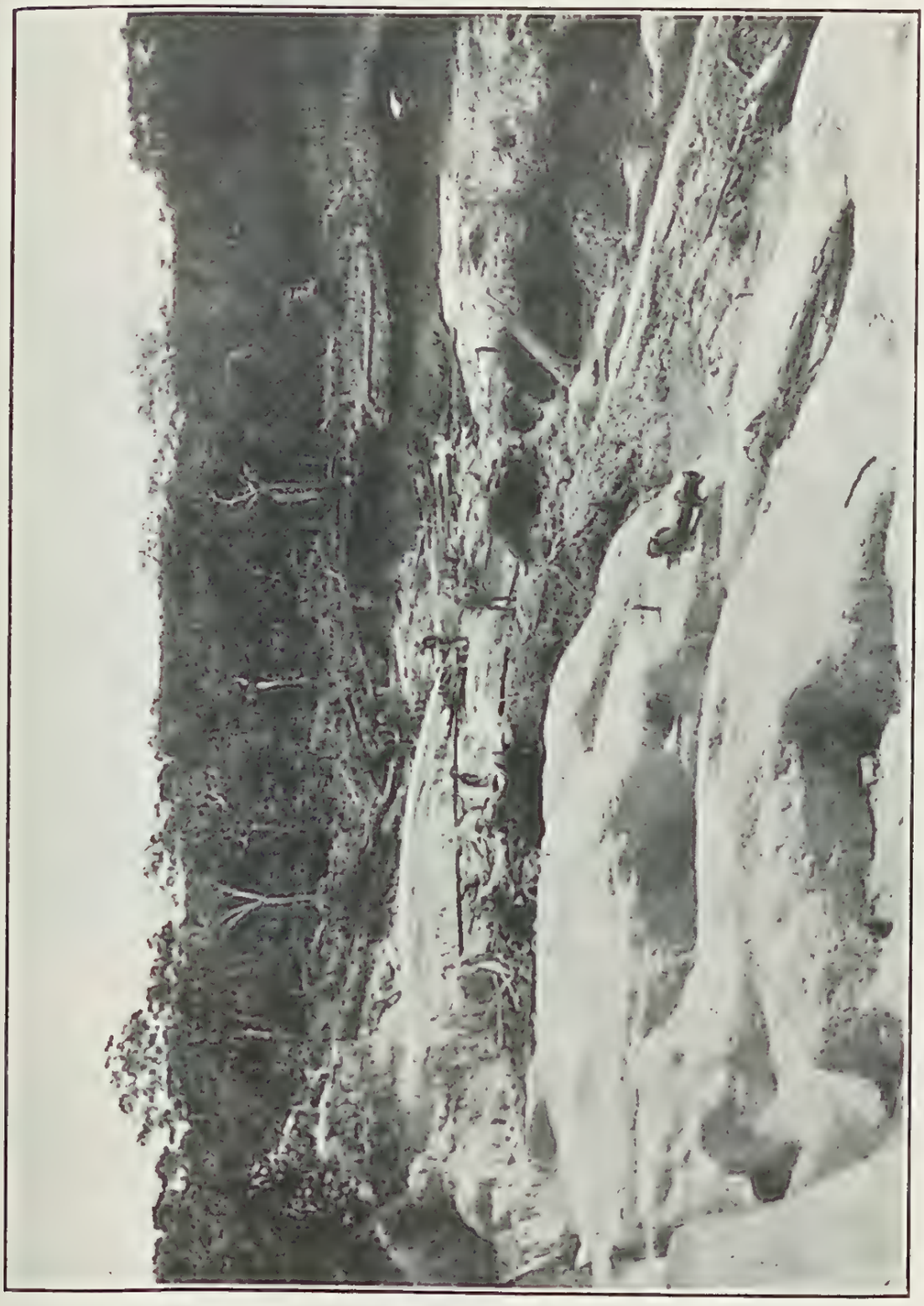


PLATE 36.—GRASSTREE UNITED (BOLEN AND BATHE'S) CLAIM, GRASSTREE. [*Photo., Spearritt.*

Quartz veinlets, frequently carrying a little tinstone, are seen to traverse the granite bottom, striking in a north-west direction.

The tinstone assays about 76 per cent. in bulk, the maximum bulk assay up to the present having been 76·4 per cent. Carriage on supplies from Cooktown was £5 per ton at the time of my examination of the field in 1914. As showing the Recent age of the deposits worked here mention should be made of the finding of three stone tomahawks embedded in solid washdirt at a depth of 9 ft. from the surface. From an area of roughly 8 acres the owners have obtained over 100 tons of tinstone. This ground had been previously tried by hand methods and abandoned by various prospectors, and it was not until Messrs. Bolen and Bathe succeeded in laying on an efficient water supply for the working

[*Photo., Spcarritt.*

PLATE 37.—BOLEN'S DAM ON THE ANNAN RIVER ABOVE GRASSTREE.
To supply the Grasstree United and Romeo Pioneer Claims.

of the property that the real value of this claim became apparent. Operations were commenced by them in 1905. The pipes in use were made on the ground at a total cost of 2s. per foot (11½-in. diameter pipes), which price compares more than favourably with the cost of 3s. per foot that had previously been incurred for smaller (7 in.) pipes landed on the ground ready made. The average depth of the alluvial is about 9 ft. at the present time, but a distinct deepening of the ground can be seen to occur in an upstream direction. The tinstone is mostly of medium grain and of various colours. Three men are employed on this claim, which has at least fifteen years of highly

remunerative work ahead of it at the present rate of progress by sluicing the stream banks as well as upstream. The sluice-boxes in use are 276 ft. in length by 4 ft. in width and 18 in. deep, with a "fall" of 2 ft. per chain.

The natural "fall" of the bottom averages 7 in. per chain. A characteristic feature of this claim is the presence of seams of practically pure tinstone met with along the bottom in the washdirt; at the time of my visit in December, 1914, a bed of rich washdirt 3 ft. in thickness was exposed along the whole face of the workings. It is interesting to record that at this particular property it has been observed that in nearly every instance where the washdirt is rich the overburden is poorer than where the

[*Photo., Spearritt.*

PLATE 38.—ELEVATOR AND SLUICE-BOXES, GRASSTREE UNITED CLAIM, GRASSTREE.

bottom is poor; this naturally has the effect of equalising the output from a given area. Good tin values have been located in the alluvium existing some distance back from the stream on a low ridge along the right bank.

Taking into consideration the small amount of money that has been laid out on this claim, its excellent water supply and the generally low costs of working, I am of opinion that the Grasstree United is one of the most payable mining propositions existing within the Annan River, &c., tinfields described in this report.

The Warden reports a return of 12¾ tons of tin from this property for 1914, of which total 4¾ tons only were sold owing to the low price ruling, the value of the quantity disposed of being £532.

Hazel Claim.—On Pig and Whistle Gully, a small left-hand branch of the Annan River; about half a mile north of the Grasstree United claim. This gully was previously worked by Messrs. Bolen and Bathe, and till recently by Baxter, but at the time of my visit was being mined by a small party of Germans and Austrians. Water for sluicing was being obtained from the Grasstree United tail race. The bedrock and the sur-

[*Photo., R. Graff.*

PLATE 39.—ROMEO PIONEER CLAIM, GRASSTREE.
Pipe column crossing Stony Creek, in dense scrub country.

rounding country here is of granite, the rock in the bed of the gully being fairly well decomposed. The tinstone occurs in patches through a mass of small granite boulders; it is of coarse grain and assays up to 75 per cent. The average depth of ground sluiced is about 4 ft. A little tinstone is obtained along the well-developed cracks which traverse the bedrock. Leaders of quartz striking in a direction W.20°N. are running through the bottom but no tinstone has hitherto been observed in them. The returns from this area have of late been very satisfactory.

Tinstone has been found to occur on the surface along this ridge for a considerable distance, having been obtained every-

where along the water race during the excavation of the latter by Bolen and Bathe some years ago, and the existence of a greisenised granite formation carrying tin on the top of this ridge, between Pig and Whistle Gully and the Grasstree United appears highly probable.

Romeo Pioneer.—This claim is situated in scrub country near Stony Creek, a left bank tributary of the Annan River, a short distance south of the settlement of Grasstree. The tail race empties into Stony Creek about ¾ mile above the junction of the latter with the Annan. The average depth of ground being worked at the time of my visit in December, 1914, was about 8 ft. The bottom rock consists of soft granite with a rather uneven surface. Very little tin occurs through the overburden; it is considered by the owners (Messrs. Bathe, Doolan, Bolen, and Bathe) that the best tin values are found along the southern side of their workings and a considerable area of scrub country has been felled here in consequence, preparatory to working in that direction.

Water for sluicing purposes is conveyed by means of a 12-in. diameter pipe line from the same dam at Bolen's Falls, on the Annan River, which supplies the Grasstree United Claim. Some 50 chains of pipe line was constructed, the material used for the purpose being 18-gauge galvanised flat iron riveted at twenty-six places in a length of 3 ft. and then soldered and dipped in tar. The pipes were made in 12 ft. and 15 ft. lengths. It is estimated that 130 ft. of head pressure is available at the working face. The sluiced material is elevated about 21 ft. vertically into 6 ft. wide sluice-boxes.

Only a limited number of the fairly numerous quartz leaders through the bottom have been found to carry tin but where such does happen the tinstone occurs in seams alongside the leaders, having been broken down during the decomposition of the granite; these leaders strike from S.E. to E.20°S. As in the case of the Grasstree United the tinstone occurs more or less in the form of seams lying along the bottom of the wash dirt. Assay value of the tinstone 76 per cent.

The average yield per cubic yard appears to have worked out at from 2½ to 3 lb. of tinstone. Up to the time of my examination in December last some 16,000 cubic yards treated gave a yield of 16 tons 14 cwt. During the five years the syndicate has been working here an area of about 7 acres has been worked out, and there is certainly sufficient ground still to be worked here that will take a long period of years to treat. A certain proportion of the ground sluiced by the present

owners had been worked by early tin miners, but the returns were not payable under hand labour methods. Four men are employed here, working three shifts. Near the bottom of the workings a small gully enters Stony Creek, known as Black Snake Gully; this gully is stated to carry rich tin values.

To the northwards of the claim a gully known as the Rise and Shine has been worked to a small extent with payable results; this gully is crossed by the pipe column.

The Warden's annual report gives the yield from this claim for the year 1914 as being 16¾ tons, of which total 8 tons were disposed of for £861.

[*Photo., Spearritt.*

PLATE 40.—ROMEO PIONEER CLAIM, IN DENSE SCRUB COUNTRY AT GRASSTREE. Showing the sluice-boxes, and also an area of scrub felled to facilitate future sluicing operations.

Jackeroo Claim.—Also owned by the Romeo Pioneer holders. I am informed by the owners that the area comprised within this block is an old 50-acre lease in the dense vine scrub country stretching away from the Romeo Pioneer block. At the junction of Jackeroo and Stony Creeks the ground is very level and material would need to be elevated. This creek heads in Yorkey Range. The alluvial deposits along it are mostly deep, bore holes down to 18 ft. in depth having ceased when striking buried logs at that depth. A considerable area has been worked along this creek many years ago, and also back from the creek

for a couple of chains in places. Much of the gravel is composed of slate fragments. Undoubtedly a considerable area of ground is available here for tin mining, providing some such appliance as an hydraulic dredging plant is used. At the head of Jackeroo Creek a little gold is sometimes obtained whilst sluicing for tin.

Tierney and Gilmaney's Claim.—About 1 mile east of Romeo in scrub country on Davis's Gully, a left bank tributary of Stony Creek, which latter it joins about 12 chains below the working face. Water for sluicing is obtained from Stony Creek by a race ¾ mile in length; this race gives usually an eight months' efficient supply. The average depth of the ground treated is about 15 ft., the maximum depth reached so far being 26 ft.; the overburden consists mainly of a heavy dark clay, the bottom being of soft granite. The tinstone is found to be practically confined in range to the lower 2 ft.; very little stone occurs in this wash dirt. The tinstone assays from 70 to 74 per cent. Work has been carried on here by the present holders since 1893, during which time it has been found that the values are fairly evenly distributed. The tinstone is of medium grain and is accompanied by a moderate amount of black sand. No gold or gemstones are recorded from this area. Unfortunately it is not possible to obtain a good pressure of water here owing to the level nature of the country. About 20 chains in length have been worked here in all. The packing charges from Cooktown at the time of my visit in December, 1914, were £5 per ton.

Finnegan's and Mount Finlayson.

The area known as Finnegan's is situated on the steep slopes of Mount Finlayson at a height of roughly 1,000 ft. above the Annan River, which separates this district from Grasstree. Most of the area is covered with dense vine scrubs.

Some years ago Messrs. Bolen and Bathe constructed a flume of great length in order to take water from Horan's Creek on Mount Finlayson at a point 1,860 ft. above the Finnegan's workings. The construction of this now largely broken down flume entailed an immense amount of physical labour, the whole of the sawn boards having to be carried up the mountain on the men's shoulders. Portions of the flume consisted of the hollowed out barrels of palm trees; owing to the enormous "fall" it was found that only an extremely small-sized flume was necessary to carry the requisite sluicing supply. Bolen's old dam is at an elevation of 2,200 ft. above the sea, whilst the altitude of the Top Gap on Mount Finlayson is about 2,750 ft., the summit of the mountain being 3,700 ft.

Only two claims were being worked at the time of my visit in December, 1914—namely, those of Messrs. H. Coleman and J. Johannsen respectively.

Hopeful Claim.—H. Coleman; located at Finnegan's, near the right bank of Finnegan's Creek, at an elevation of about 1,500 ft. above sea level; Coleman's residence, which adjoins his claim, is close to the south-west corner of M.L. 237. Water for sluicing is obtained from Rocky Creek, about 20 chains above the claim. Work is being carried on with a hydrant, about 50 ft. of pressure being employed. There is usually an abundance of water for eight months in the year; roughly one box head is available in the dry season. The average depth of alluvium exposed at the time of my visit in December, 1914, was 8 ft. The bottom consists of soft granite, and is occasionally traversed by small quartz leaders striking north-westerly. A large area of ground has been sluiced hereabouts, the average yield being 1 lb. of tinstone per cubic yard. The tinstone is shotty and fine-grained, assaying 72 per cent. A little tin occurs evenly throughout the overburden. The owner has been working here for the past seven years, but the ground in this vicinity was also worked in the early days to a considerable extent.

Great Landslip Claim.—Johan Johanson; several isolated patches of ground have been sluiced with water brought a distance of 1½ mile from Gorge Creek, a tributary of Horan's Creek, by pipe line for portion of the distance. The alluvial treated is mainly very rough stony ground resting on a steep slope. Aneroid level here 1,700 ft. above sea level. The location of this claim is near the corner of Mineral Leases 200 and 201. A tin-bearing leader was struck close to Johanson's house and worked by a deep trench for a considerable length, with, it is stated, payable results; strike north-west.

Fiery Cross (?) Lode.—A tin lode occurs on the side of Mount Finlayson above Finnegan's. Strike of lode north-west. This mine was, I was locally informed, worked a few years ago by Mr. Madden, of Cooktown, but no work had apparently been carried on here for some time past. A trial crushing of 5 tons of ore is said to have yielded 3 per cent. The ore consists of bluish quartz in granite, with odd blebs of tourmaline. The width is about 18 in. A shallow shaft was sunk and a little trenching done along the lode. A second shaft (shallow) has also been sunk on the south-eastern end of the lode, the latter being traceable, at intervals, for some distance further on in that direction. The width of ore exposed at this lastnamed shaft is

3 ft. at the top and 15 in. at the bottom, the stone being bluish quartz with some chlorite. The tinstone appears to be fairly evenly distributed through the lode.

Mount Romeo.

Kimberley Claim, owned and worked by Messrs. J. Muir and J. Wilson, who commenced operations here 27 years ago; situated on Kimberley Gully, a right-bank tributary of the Romeo Branch of the Annan River, about 16 chains above the junction of the main creek.

Water for sluicing is obtained from Romeo Branch by a race 1¼ mile in length, including about 9 chains of fluming. This flume is one of the highest ever erected on the Annan River Tinfield, being 50 ft. above the water level of Baird's Creek, over which it crosses; it is constructed of bloodwood uprights supporting pencil cedar fluming, the dimensions of the latter being 1 ft. by 10 in., and the "fall" 3 ft. in 260. It was made originally over twenty years ago, being supported on growing trees which had been cut off high up, but the top of these stems rotted away in time and timber had to be introduced into the construction. Kauri pine was tried for the flume boxes, but this timber lasted for only one season, the pencil cedar fluming now in use having proved infinitely more durable. An excellent photograph of this fine piece of constructional work has already been published in Mr. Cameron's report.*

There is usually an eight months' efficient sluicing supply available; there is sufficient "fall" for sluicing though the bottom is rather level. The tinstone is medium-grained and runs from 74 to 76 per cent.; a very little iron sand (ilmenite) is present. On lower end of the claim the average depth is 18 ft., a small quantity of tin occurring through the overburden; the lowermost 2 ft. is considered as the pay wash, which latter consists largely of slate pebbles and rests upon a bumpy soft granite bottom. The distribution of the tin values may be said to be patchy.

In the early days of mining, when the main stream bed was being worked, several "colours" of gold were obtained. Quartz leaders striking east and west traverse the granite bedrock and occasionally carry small amounts of tinstone. A considerable quantity of granite boulders up to 1 ft. in diameter are met with through the overburden upstream from the present working face. In this upstream section of the claim an average

*G.S.Q. Publication No. 210; plate III.

depth of 20 ft. is attained along the edge of the dense scrub in which the claim is partly situated. The tin is here of still higher grade than that already mentioned as being won from the lower workings. The bottom rises sharply near the banks and the width of the alluvial deposit is in consequence probably very small here. The ground still remaining to be worked is probably too rough and stony to be of much value as a tin producer in the future.

Baird's Creek Claim.—Owned and worked by Messrs. T. Mahoney and J. Sullivan, who are working along Baird's Creek at a point some 20 chains above the junction of the Romeo Branch, of which latter it forms a right-bank tributary. The ground is mostly deep, with terraces on the higher ground away from the stream channel. The bottom is of soft granite. Water is obtained from Romeo Branch by a race 1¼ mile in length, including a certain amount of fluming. The tin is identical in character with that seen at the Kimberley Claim, and assays 75 to 76 per cent. Operations have been carried on for the past twenty-six years, and a considerable area of ground considered by the owners to be payable still remains to be treated.

Tonkins Gully Claim.—Owned and worked by David Ross-Kelly. This claim is situated on Tonkins Gully (a left-bank tributary of the Romeo Branch) along the southern slope of Wilkie's Hill. Work was commenced here in 1904. The average depth of the ground worked has been 16 ft., the material resting upon a soft granite bottom. The tin occurs in a bouldery (granite) washdirt, a very limited quantity being found through the overburden from the surface downwards; it is of high assay value and frequently occurs as "specimen" tin. Water to treat this ground is obtained during the wet season by means of contour drains. Numerous small tin-bearing leaders through the granite bottom have been exposed, the general strike being about north-westerly.

Campbell's Claim.—Owned and worked by Samuel England for the past four years, located on Campbell's Creek, a left-bank branch of Clear Water Creek, which is in turn a left-bank tributary of Romeo Branch. The average depth is about 15 ft. The tinstone is coarse and assays about 73 per cent. in bulk. The topmost 3 ft. of this ground usually contains the best tin values, or, in other words, the ground here may be classed as "surfacing." England is now working along the old terraces hereabouts. No permanent water is easily available for sluicing, and work is more or less restricted to the wet season. The "bottom"

for all practical mining purposes is composed of cemented detrital granitic material, through which small amounts of alluvial tin have been found; this "bottom" is found to run in ridges about 100 yds. apart as a rule.

Coronation Claim.—Owned and worked by Messrs. Geo. Hitchcock and Maurice Davies; Mineral Leases 220 and 223, on the southern slope of Ogilvie's Hill. This ground was previously worked for many years by Yates, later on by Hy. von Bremen, then by John Skirving, and finally purchased by the present owners from Mr. Skirving. Water for sluicing is obtained from Granite Creek, a left-bank tributary of the Bloomfield River, by an old race some 3 miles in length, inclusive of a considerable proportion of fluming.

There is usually a ground sluice-head of water available for about eight months in the year from this race in its present somewhat dilapidated condition. From the race intake to the head of the claim there is stated to be a "fall" of 600 ft., whilst the present pipe column affords only 160 ft. of head pressure: the pipes are of 18-gauge galvanised iron, 7 in. in diameter and telescoped. A 1½-in. tip is employed during the wet season and a 1¼-in. one for the remainder of the sluicing period.

The tinstone assays on an average 72 per cent. in bulk lots. Tourmaline and a little ilmenite are present with the tinstone. A strongly marked quartzose leader, traceable for a considerable distance on the surface and striking W.20°N. and carrying a little tin, traverses the granite in the northern portion of the No. 1 face; a little mispickel occurs through this leader. The granite is distinctly red in colour and is apparently assuming a harder character in depth. Roughly 6 tons of tinstone have been won here from an area of a quarter of an acre. The average depth reached on the northern face is 15 ft., with a maximum of 20 ft. A considerable quantity of granite forkings had to be handled. Prospecting boreholes below the level of this cutting are reported by the owners to indicate the existence of an extensive area of stanniferous decomposed granite below. On the ridge above the No. 1 face there exists a hard bar of aplitic granite, and the best tin values were found below this formation.

At the No. 2 face the depth of ground treated is from 6 to 30 ft. Several bluish quartz leaders accompanied by tinstone traverse the granite striking W.30°N. The north-western end of the cut was worked many years ago for true alluvial tin. Seams of kaolin traverse the granite in a direction approximately N.15°E. The decomposed granite here is reported to yield

half an ounce of tinstone to the dish in the present face; a total yield of 5½ tons has been obtained from 8,000 cubic yards treated. The contact of the slate and granite formations occurs close to this face. Some of the tin obtained is coated with ironstone.

Kaolinic seams run parallel to the leaders. The granite, which is in large part kaolinised, carries fine-grained grey tin of a stated average yield of ¼ oz. to the dish. Along a gully, extending northerly up to Ogilvie's Hill, between the Nos. 1 and 2 faces, alluvial has been worked with good results for a length of ¾ mile up stream, and shows decomposed granite in the sides and bottom. Several shallow shafts were sunk in this soft rock and show the granite to carry fine-grained tin of a

[*Photo., Spearritt.*

PLATE 41.—CORONATION CLAIM (HITCHCOCK AND DAVIES), ROMEO.
Decomposed stanniferous granite similar to that seen at Daly's Face, Collingwood, Lode Hill, &c.

brown colour. About 90 tons of alluvial tin are reputed to have been obtained in the early days from an area of shallow depth, 3 chains long and 1 chain wide, situated close to the right bank of Romeo Branch, near the present tail race. About 200 ft. of "fall" occurs in the main creek between this claim and Mahoney and Sullivan's dam. A bar of hard granite is crossed by the creek below the workings. Slate shows in the Romeo Branch at a point about 100 yards above the entry of the tail race.

There can be no doubt that a large extent of easily treatable decomposed granite occurs on this property, but before any very great sum was spent in laying on an efficient water supply it would be advisable to first carefully test the ground by systematic boring in order to delimit those portions which are payable.

Stringer Claim.—Owned and worked by Wm. Groom; situated in scrub country on the ridge above the right bank of Sunday Gully, the latter emptying into Romeo Branch about 500 yards down stream. This ground was first worked as "surfacing" but has now rapidly deepened as higher ground is being approached. The tin is evenly distributed from top to bottom of the deposit. Very little stone occurs through this alluvium. The tinstone is coarse-grained and assays 73 per cent. in bulk. The bedrock is composed of soft granite.

Water for sluicing is obtained from Romeo Branch by a race 1½ mile long, including a siphon over Sunday Gully; the siphon was preceded by a flume 51 ft. above the water level of the gully and hence the highest flume ever constructed in the Annan River tinfield. Water is available in sufficient quantity for requirements throughout the year; about half a ground sluice-head is usually employed. Work has been carried on at different portions of this claim for the past twenty years. It is intended to continue working up the ridge providing the owner can install some mechanical contrivance for elevating the water to the requisite height.

Ti-tree Creek.—A left bank tributary of Romeo Branch, which latter it joins close to Meundell and Morris' claim on Lower Romeo. The slate and granite contact occurs along this stream. A limited amount of mining for alluvial tin has been carried out at odd places upstream from the track leading to Mount Poverty; small falls occur in the hard slate country immediately below this track.

Campbell and Griffiths' Claim.—Situated on Tony Quoin's Gully, which joins Romeo Creek at the Platypus claim. Water is obtained from Romeo Creek at a point close to Groom's dam. The prospectors are working along the bed of the gully; average depth of alluvium about 10 ft. The tin occurs in the bottom washdirt, which latter rests upon a slate bedrock.

Taylor and Downe's Claim.—On the left bank of Romeo Creek just below F. Moore's house; a moderate area has been worked here, the average depth of the ground being about 10 ft. The washdirt here contained payable tin but the ground to be treated is cutting out rapidly up the ridge.

Platypus Claim.—Owned and worked by F. Moore; situated on Romeo Creek near the Cooktown-Grasstree road. Water for sluicing is obtained from the Annan River by a race some 4 miles in length including 33 chains of fluming; the fluming took ten months to erect. Three men in all are usually employed here, working two shifts. Sufficient water is available for requirements throughout the year; at the time of my visit in December, 1914, one and a-half ground sluice heads were available. 130 ft. of head pressure is obtained, operating a nozzle and an elevator (1½ in. tip). The maximum height to which the material has been elevated so far is 20 ft., the average being about 17 ft. There are estimated to be 50 acres of ground on this property suitable for dredging. The average depth of alluvium treated to date has been from 18 to 20 ft., tin occuring in the 9 ft. of washdirt. The alluvium is rather stony, but fortunately the stones are not of large size; the material is a characteristic deposit of creek-borne alluvium. The distribution of tin through the washdirt is comparatively even. The tinstone is medium-grained and assays 72 per cent. in bulk parcels.

Operations commenced here early in 1911, since which time about 14½ tons of tinstone had been won to the end of 1914 from an area of roughly 4½ chains in length by 1½ chains in width. The wash stones comprise slate and granite; the bottom is of blue slate and fairly hard with a bumpy surface. Several years of profitable work are undoubtedly ahead of this claim. It is the intention of the owner to work upstream along Romeo Creek. It is of interest to record the fact that the rising ground along the flats have so far been proved to be overlain by the greatest thickness of washdirt, whilst areas over which surface depressions occur have usually only about 13 ft. of alluvium.

Swamp Claim.—Owned and worked by Harry Barnard; situated on Butcher's Gully, a right bank tributary of Romeo Creek, which latter stream it joins just below the present claim near the Cooktown-Grasstree road. The ground has been worked up from the creek junction. Work was commenced here about five years ago; much of the richer ground had been previously worked during the early days of the field. Water for sluicing is obtained from Butcher's Gully. There is usually a sufficient supply for about eight months in the year by using a dam; approximately one sluice head is generally available. Barnard is working up the bed and along either bank of the stream. The alluvium averages 6 ft. in depth of which thickness the lower 2 ft. constitutes the tin-bearing wash dirt. The tinstone is medium-grained and assays 74 per cent in bulk. The bottom

is of slate whilst the wash dirt contains mostly granite and quartz boulders about 6 in. in diameter.

There still remains some three years ground to be worked on this claim. The tin values have hitherto been found to be practically confined to the main stream channel itself, the banks being more or less barren. The average yield of tinstone obtained here has been 25 cwt. per annum. Several flattish grains of gold obtained during sluicing were shown to me.

Mount Poverty.

Although not located within the watershed of the Annan River, this district is in such close proximity thereto that it is usually included under the Romeo district. An examination of the area was made by me in December, 1914. The situation of the claims is close to the East Normanby River, a short distance from the watershed separating those waters from the Annan. An aneroid reading gave the height of this divide on the road as being 1,820 ft. above sea level, another reading of interest being that of the camp on the East Normanby River at Poverty—1,700 ft. The distance from Cooktown is about 37 miles; from the turn-off from the Romeo road to Mount Poverty is 7 miles.

Granite makes its appearance at Stony Creek, about 4 miles along the track from F. Moore's house at Romeo, the intervening country being slate.

The principal workings are those of *Messrs. W. J. Wales and party,* who have lately been employing about four men on an average at their dredging claim 1181 (127 acres). A dray road between Nunn's Forks at Helenvale and this claim was constructed by the Messrs. Wales about two years ago; for this work a sum of £200 was allotted by the Government in order to make possible the carting of machinery to the site, and a very considerable amount of work indeed was carried out in the nature of road cuttings, many of which latter had to be blasted out of hard granite; considerable work was also entailed in replacing the steep track known as the Zig Zag by a better route for carts. The present packing charge to Poverty from Cooktown is £6 per ton. The pumping machinery was transported from Byerstown about eighteen months ago. At first the water for sluicing was pumped from the East Normanby River direct to the working face; but it is now delivered into a small supply dam above the workings and thence runs on to the face by gravitation. There is always a good supply of water in the river here. The tinstone obtained is medium-grained and, I am informed, assays about 72·6 per cent. in bulk parcels.

A considerable area of slate-derived alluvial, with much ironstone conglomerate, has been worked along the right bank of Higgins' Gully, which latter tributary joins the main river on the right bank close to the camp and pumping station. The bottom is here of hard slate. The overburden is partly composed of tight clayey material. Only a small amount of black sand is met with. There still remains to be worked a large area of ground carrying a little tin. In the early days of this field the ground was largely worked by means of a great number of drives. The ironstone conglomerate (of Recent geological age) is frequently studded with tinstone.

In the cutting known as The Slide, near Nuggety Gully, a great thickness of yellow clayey alluvium has been exposed. The overburden here carries a little tin, but the bottom wash essentially contains the values. This washdirt is composed largely of greisen and tourmalinised quartz pebbles. Though not actually exposed the bottom is here most probably slate. Granite occurs a short distance easterly from this cutting. No work has been done at this site for the past twelve months, and the ease with which the overburden slips down in great banks when once the face is opened up has resulted in the latter being obscured from a thorough inspection.

It is the intention of the owners to pump water up the hillside in order to work this and other deposits on the property. Slugs of tinstone up to as much as ½ cwt. have been found at times in Nuggety Gully by R. Trenam. Very little fall for an efficient get-away of the tailings is available without first cutting through a hard slate bar in the river some distance downstream from the workings. I understand that Messrs. Wales and party have in mind a proposal to bring in water from the river by means of a long head race, though it is very questionable if sufficient pressure could be thus obtained without drawing the water off at some point so high up the course of the East Normanby that an adequate sluicing supply would not always be available.

Green's Gully, a right-bank tributary of Higgins' Gully, has been worked at various times by Holmes and others, and also to a limited extent recently by the present owners near the head of the gully. The overburden is chiefly gravel and carries tin from the surface downwards. Water for sluicing is available only during the wet season. It is said that a considerable amount of tin has been won from this gully since it was first discovered.

Messrs. Wales and party were absent from their property at the time of my visit, but I am informed that their property

is known by them under the name of the *Surprise Tin Sluicing Company.* Power for lifting the water is at present furnished by two small boilers, but the capacity of these appeared to me to be altogether inadequate should the owners decide to carry on work on an important scale. These boilers are stated to burn about one cord of wood per shift; wood cut in 3 ft. and 3 ft. 6 in. lengths; usually oak and bloodwood are burnt by reason of their local abundance.

A considerable area of alluvial occurs on the flat along the right bank of the river on this claim, but no testing appears to have so far been done here to ascertain if payable values exist. Should values be found it would be of great importance to future operations, as if this area could be worked out and the material sluiced be subsequently transported downstream out of the way by flood waters, a much needed tailings dump for the main areas up the ridge would be provided.

The Warden's annual returns for the five-year period 1910 to 1914 inclusive give the accompanying totals of tin won from Mount Poverty during those years:—

	Tons	cwt.	qr.	lb.	Value. £	s.	d.
1910	3	8	1	15	325	12	5
1911	2	10	3	2	302	5	1
1912	1	1	2	26	143	0	0
1913	2	1	1	22	259	17	2
1914	0	14	1	0	84	15	0
Total ..	9	16	2	9	£1,115	9	8

PART 2.—TINSTONE ON THE COOKTOWN FIELDS.

The element *Tin* very rarely occurs in a native state, though such has actually been observed at several places in different parts of the world. By far the greatest portion of the metal won is combined with oxygen in the form of the mineral *cassiterite* (also commonly known as *tinstone, tin ore, or black tin*).

Cassiterite is a heavy mineral (specific gravity 6·4-7), hence its common occurrence in alluvial deposits formed from the denudation of neighbouring stanniferous formations. It is fairly hard, being barely scratched with quartz, but it is somewhat brittle, yielding a greyish to white powder, by which means it can often be differentiated from other black heavy minerals, *e.g.*, magnetite, wolfram, and ilmenite. The maximum quantity of metallic tin present in cassiterite is 78·6 per cent. The lustre of tinstone crystals is adamantine. In this district, the assay value of the alluvial tin concentrates is usually much higher than that obtained from lodes. When theoretically pure, tin-

stone is colourless to white, the presence of impurities such as iron, manganese, arsenic, &c., tending to make it become dark and nearly opaque; hence those individual fragments which are white, amber, or ruby in colour, give a higher assay for metallic tin than the common black variety.

It is doubtful if any extensive tinfield in the world—certainly none in Australia—yields cassiterite of a higher assay value in bulk lots as sold than the one now under review. I am informed by Mr. Brickwood (assayer and tin-buyer at Cooktown) that he once assayed a *picked* sample of tinstone from the Sand Hills claim, Mount Hartley, which returned the extraordinary high assay of 77·4 per cent. of metallic tin. Of the sections of the field which have yielded very high grade tinstone (in bulk) mention should be made of the following:—Shipton's Flat (up to 76·6 per cent.), Tabletop, Buck Rock, Sand Hills, Grasstree (up to 76·2 per cent.); Bloomfield Scrub, Lower Tableland (up to 76 per cent.), Romeo (up to 76 per cent.), Nolan's Gully (up to 75 per cent.), Lorna Doone (75·8 per cent.).

The most abundant white tin seen by me was at R. Henderson's claim at Lower Tableland, but it also occurs in notable quantity at Shipton's Flat, Tabletop, Lion's Den, Home Rule, Three Mile, and other localities. An interesting occurrence of pink, white, and slime tinstone is that of Norris' Lode (Mount Amos) described elsewhere. Ruby tin occurs at Lion's Den, Shipton's Flat, Lower Tableland, &c.

At the present Home Rule workings a curious fact is that the colour of the tinstone varies with that of the underlying decomposed slate formations. The coating of tinstone with oxide of iron is at times a feature of portions of the Coronation claim at Mount Romeo, portions of the Mount Poverty district, and at times also of Lynch's and Roseblade's Gullies, Tableland.

As few miners are adept in the use of the blowpipe, the accompanying description of a very old but recently revived method of rapidly testing for tinstone, to which my attention has been kindly directed by Mr. J. A. Smith, Mineralogist of the Queensland Geological Survey, may be of interest:—

"Place the piece or particles of material to be tested in contact with zinc, and cover with fairly strong hydrochloric acid; if tinstone it will become coated in a minute or so with a thin layer of metallic tin, which if of sufficient size will take a polish on rubbing between the fingers.

"The chemical reaction involved appears to be that some of the hydrogen gas, given off by the action of the acid on the zinc,

unites with the oxygen of the tinstone to form water, leaving metallic tin on the surface of the specimen. Excess of zinc must be present, otherwise if the acid is in excess after the zinc is all in solution it will in course of time dissolve the coating of tin. Tin ore alone is infusible before the blowpipe, and is proof against all acids, hydrogen being the active agent in this test.''

PART 3.—MINERALS OTHER THAN TINSTONE.

Although several different minerals of more or less economic value have been recorded from the Cooktown tinfields, it may be said that generally speaking this field is characterised by an absence of any noteworthy deposits of other metals, in this respect differing vastly from the other two important tin-producing centres in the State—namely, Herberton, and, in a lesser degree, Stanthorpe.

Wolfram.

Perhaps the only mineral that could possibly be described as having attained, so far as mining operations are concerned, to any economic importance at all, and even then apparently not payable, is wolfram. This mineral has been recorded as occurring, in totally insignificant quantity, at a few localities where tin-mining has been carried on, including the following:—

(*a*) Lode Hill workings, China Camp; the mine foreman, Mr. Geo. Symons, informs me that a little wolfram has been obtained from the open cut workings here; but that none has been noticed recently.

(*b*) Phœnician tin lodes and Mount Amos.

(*c*) Mount Hartley Wolfram Lode.

Locality (*c*) (Mount Hartley Wolfram Lode) is the only place where an attempt has been made to mine for wolfram. The accompanying description has been largely made from information kindly supplied by old residents who are acquainted with the workings, most of which latter are now inaccessible.

Mount Hartley Wolfram Lode.—Situated in granite country, on the northern slope of a densely scrub-covered ridge above the right-hand branch of Mount Hartley Creek, about 5 miles easterly by track from Rossville and a quarter of a mile north of the Mount Hartley track, and under the foot of Mount Hartley. I examined about two chains in length of the main tunnel, at which point a fall of earth bars further safe ingress. The hanging-wall of the lode is well defined and shows slicken sides. The quartz is extremely fine-grained in structure and seamed with very fine-grained tourmaline. The granite country rock is mostly of the porphyritic type, the wall rock of the

lode carrying a notable proportion of white mica. Numerous shallow cuttings have been made for half a mile in length along the outcrop, exposing a reef averaging 2 ft. in width. At the shaft situated at the southern end of the outcrop the granite "country" is much more acidic and fine-grained in type than at the northern (tunnel) end; some of the quartz met with here is chalcedonic. The strike is S.30°E. with a slight westerly underlay.

No work has been carried on for a lengthy period and the accompanying notes have been collected from the miners formerly engaged here:—The lode was originally discovered about 1889, during the sluicing of a gully for tin; it was very rich in wolfram at the surface, where first found. The wolfram occurred in small bunches along the lode at isolated points along the outcrop.

Messrs. Symons, Fletcher, and P. Dibney first worked the lode, and at the same time Messrs. J. Bowditch and D. Kerr obtained 6 cwt. of wolfram about twelve years ago. Mr. Symons informs me that his party obtained fifteen bags. The wolfram obtained by the latter party assayed 72 per cent. of tungstic acid in bulk.* The lode was subsequently worked by Asimus and Sons, who drove a tunnel in along the course of the lode for 200 yards, the lode carrying small values only of wolfram. The main shaft was sunk by them to a depth of 70 ft., and is stated to have showed splashes of wolfram, the lode averaging 2 ft. 6 in. in width. The wolfram occurred mainly in the massive form. A little arsenical pyrites is present and an insignificant amount of copper was seen in a vein at the end of the tunnel. From a consideration of the country rock, the ore-body, and the amount of prospecting already carried out along this lode, I am in no wise hopeful of it ever proving to be a payable wolfram proposition.

Gold.

Gold occurs in numerous localities throughout the tinfields, more particularly in the alluvial deposits resulting from the denudation of the slate country. It is obtained, in negligible quantity and of little more than scientific interest only, during the final streaming operations connected with tin-dressing. Claims from which gold has been thus obtained include the following:—

(*a*) Agnes Claim (Neil Jenkins) at Tabletop; odd specks of scaly gold have been obtained here.

* The maximum assay value of Wolfram is 76 per cent. of tungstic acid.

(*b*) Ross's Claim; O'Keefe's Creek, Tableland; odd "colours."

(*c*) Archibold's Claim, Mount Amos; occasional specks.

(*d*) Hurricane Gully Claim, Three-mile (Russell's); odd specks.

(*e*) Swamp Claim (Barnard's), Butcher's Gully, Romeo; several flattish grains.

(*f*) Home Rule Claim; a nugget of 1½ dwt.

(*g*) Lorna Doone Claim, Rossville; odd "colours."

(*h*) Jones's Claim, Tableland; odd "colours."

(*i*) Recompense Claim, Mount Leswell; odd "colours"; one piece of ¼ dwt., very waterworn.

The gold would appear to have been originally derived in the main from small quartz reefs traversing the sedimentary rocks rather than from the granite areas.

Molybdenite.

Molybdenite is stated to have been occasionally obtained as small scales through the tin lodes at Mount Amos and the surrounding district; none, however, was showing in the properties working at the time of my visit to that area in December, 1914.

Mr. Hedley, of Home Rule, stated to me that he had seen flakes of a mineral which was probably molybdenite in the granite country lying near Slatey Creek at the Bunks.

Since the recent enormous advance in the price of this substance a fair amount of prospecting has been done in the Cooktown tinfields, but up to the present without success. From a study of the rock formations occurring in this region, I am not hopeful of any useful discoveries being made in the area dealt with in this report.

Copper and Lead.

Copper, in the form of native copper, has been noticed in the tin lodes at Mount Amos, as also has the mineral galena (sulphide of lead). The presence of lead has been frequently detected in the cleaned tinstone as sold but the quantity has been so insignificant in amount that it has not so far been penalised for.

Arsenic.

The association of arsenic minerals with tin lodes is a feature of common world-wide experience, and the Cooktown area is no exception to the general rule. It occurs here as the mineral mispickel* (arseno-sulphide of iron) in the form

* Also known under the names of arsenical pyrites and arsenopyrite.

of narrow veins and seams through the granite. At Daly's face, Annan River Company's claim, Rossville, mispickel occurs in the form of small isolated seams and masses through the stanniferous greisenised granite, and also at times accompanying quartz leaders and quartz-tourmaline veins. Nuggets of this mineral are found when cleaning up the paddocks; they exhibit a curious smooth outer surface that has often caused the substance to be mistaken for a smelted product at first sight. The mineral has also been occasionally seen under similar conditions at Lode Hill, Romeo, and Mount Hartley (Bright Smile Claim). At the Mary Claim (S. Spargo's) at Tabletop, near Shipton's Flat, pieces of solid mispickel are not infrequently seen in the washdirt, the latter having been derived originally mainly from the denudation of granite areas.

Mispickel has also been recorded from several tin lodes at Mount Amos, Phœnician, Mount Leswell, Tableland (Lion's Den), Mount Hartley, and other localities.

Corundum.

The mineral Corundum, the composition of which is pure alumina, has been found associated with tinstone in alluvial deposits in at least two localities in the area under review, viz., at Wallaby Creek, Rossville,* and also at David Kerr's Claim on Jones' Creek, near Rossville; the lastnamed specimen weighed approximately 1 lb. The specific gravity of this substance, viz., 3·9—4·1 is sufficiently lower than that of tinstone (6·4—7) to permit of its being readily separated from the latter during streaming operations, and it is more than probable that at least a small proportion of the black sand occurring with tin concentrates is composed of corundum.

The blue variety of Corundum—the gem sapphire—is of very rare occurrence in the stanniferous alluvial deposits of this area, the only specimens of which I have learned being the following:—

(*a*) Associated with chalcedony and rock crystal in alluvial deposits, at Wallaby Creek, Rossville;*

(*b*) Hurricane Gully Claim (Hy. Russell's) at Threemile; three small stones have been found here;

(*c*) The Mary Claim (S. Spargo's) at Tabletop, Shipton's Flat; a small stone seen by the writer.

* Queensland Mineral Index, pp. 335-6.

Silica.

Silica in various forms occurs through the stanniferous lodes and alluvial deposits, the commonest form being of course that of granite-derived vein quartz. A limited amount of the clear colourless variety of quartz known as rock crystal, as also of the smoky variety called cairngorm, is seen in the heaps of "forkings" at the alluvial claims, whilst the amethystine variety, which is common on most tinfields both in Australia and elsewhere, occurs at several localities, notably at Lion's Den tin lodes, Tableland; in alluvial deposits at Lower Tableland, &c. The pink coloured variety of quartz known as Rose Quartz was seen by me in the alluvial deposit at the Eclipse Claim (J. Yeatman's) on Byers' Creek, near Rossville, also along Wallaby Creek, Four-mile Gully, Whitehead's Gully, &c. Chalcedony occurs at times in the form of narrow veins occupying master joints in the granite, *e.g.*, at Lower Tableland, but it is by no means a common mineral in this region.

The curious looking substance named Sagenite by mineralogists and known to miners under the expressive name of "grass-stone" by reason of the grass-like appearance possessed by the thin needles of rutile (titanium dioxide) enclosed in transparent quartz, has been obtained in small quantity from the washdirt at the Mary Claim, Tabletop, and also from the Buck Rock Claim in the same district. Perhaps the greatest recorded abundance in Australia of this much-debated mineral is at the Tingha tinfields, New England, New South Wales; it appears to be limited in range to the tin-bearing granites; the mineral also occurs in very limited quantity in the stanniferous alluvial deposits of Stanthorpe, also in similar deposits in Tasmania.

Kyanite (also spelt Cyanite).

This mineral, whose chemical composition is silicate of alumina, occurs very sparsely in the Recent stanniferous alluvial deposits along Wallaby Creek, notably at the Carnival Claim (Geo. Yeatman's), about half a mile downstream below Rossville, where several small fragments were shown to me for determination, having been obtained during tin-streaming operations. The specimens consisted of pale blue flattish pieces averaging a quarter of an inch across and possessing a distinct pearly lustre in the majority of cases.

The dark-coloured minerals closely associated with tinstone, and usually remaining with it until it is finally cleaned for market, are classed by miners under the name of "black sand" or "black jack," the commonest seen being tourmaline, ilmenite,

magnetite, specular iron ore, rutile, and probably a little corundum, whilst the light-coloured minerals of density sufficiently high to cause them to remain behind in the tin concentrates are monazite, scheelite, and topaz.

Tourmaline.

Tourmaline (silicate of alumina, boron, &c.) is the commonest of the dark minerals present due to the fact that both most of the stanniferous granites seen here are tourmaline-bearing and also that numerous extensive "blows" and veins of this mineral occur in various places, *e.g.*, Mount Leswell, Lion's Den, Mount Amos, &c. The existence of the segregation dykes of tourmaline rock through the granite at Daly's Face, Rossville, is described in detail elsewhere (vide Figure A). The Queensland Mineral Index contains a list of twenty-three different localities in this area where the existence of tourmaline has been recorded, but its presence is so universal that the list could safely be increased to include the name of every mine dealt with in this report.

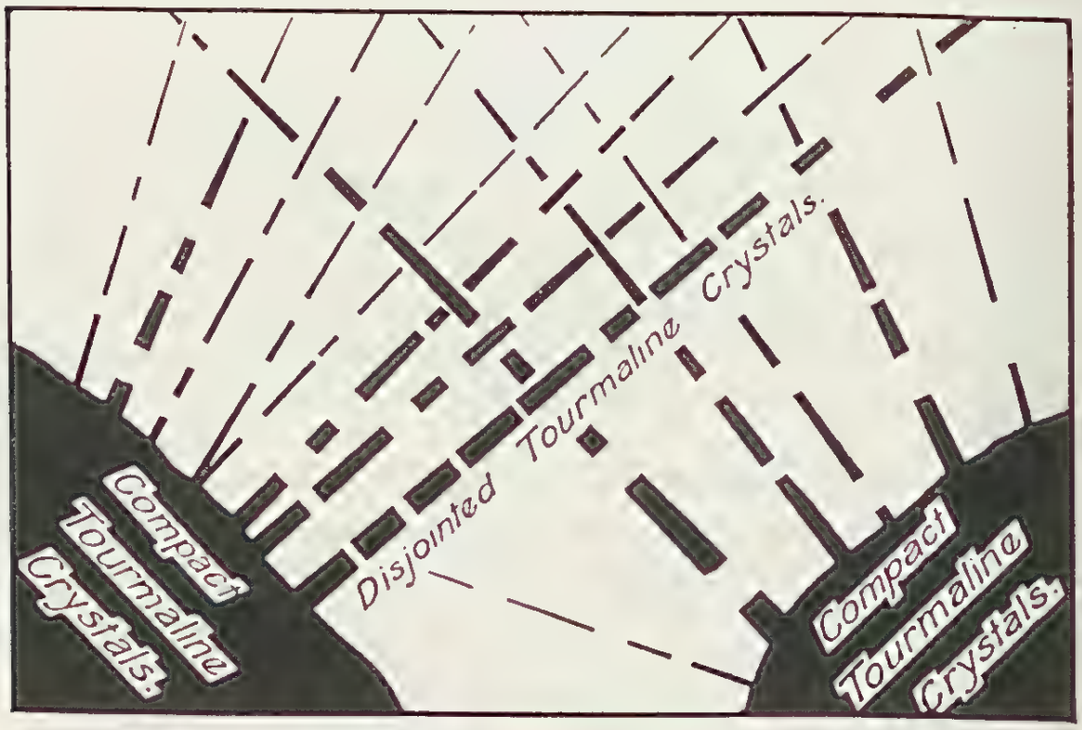


Fig. D.—Diagrammatic Sketch.
Illustrating the occurrence of radiating disjointed Crystals of Tourmaline in Quartz, Annan River Tinfield.

A characteristic structure of this mineral, previously noted by my colleague, Mr. L. C. Ball, B.E., Assistant Government Geologist, is that of disjointing in the individual crystals; disjointed crystals are fairly common in the Rossville area, as also at Mount Leswell and Lower Tableland; the structure is

most abundantly developed and clearly seen when the crystals are set in a quartz matrix, as in the case of those occurring in rose quartz at Henderson's Claim, Lower Tableland, where several specimens seen by the writer exhibited a remarkably alligator-like or bamboo-like appearance by reason of this feature, and the gradually tapering nature of most of the individual crystals. The accompanying drawing (Figure D) is a diagrammatic sketch to illustrate this somewhat unusual type of mineral occurrence.

Attention is also directed to a previous drawing (Figure B), showing a characteristic structure seen in the stanniferous granites at O'Keefe's Creek, Tableland. Whilst by far the greatest amount of tourmaline occurring in this region would be designated schorl (black tourmaline), some at least is distinctly brown in colour, *e.g.,* in portions of the Mount Leswell workings. So far as can be gathered from the experience obtained when prospecting the tourmaline masses for the rich veins of nearly solid tinstone they not infrequently contain, it has been found, at both Mount Leswell and Phœnician, that the massive varieties are more frequently found to carry tin values than in the case where the tourmaline occurs in the form of distinctly radiating well-developed crystals, whilst at the last-named area it is also considered that the presence of much fine-grained tourmaline constitutes the most reliable indicator of good tin values in the lode.

Seams of tourmaline sand, several inches in thickness, occur bedded in the washdirt at the Redivivus claim (Hinsley and Kinnerk's) in the Bloomfield Scrub.

No difficulty is experienced in removing this tinstone associate when streaming, the specific gravity being quite low (2·98-3·20) as compared with that of the tinstone.

The black variety of tourmaline seen in the Cooktown area has no commercial value whatever, the coloured stones—pink (Rubellite), and clear green, being valuable, however, as gem stones, whilst a certain limited, but nevertheless very important, use is also made of tourmaline in the construction of the optical instruments employed by mineralogists.

At the Fitzroy Bar, near McLean's claim on O'Keefe's Creek, Tableland, segregations of tourmaline ranging up to 1 ft. in diameter occur as circular patches at times, surrounded by an aureole of quartz 1 in. in width; the host rock is a hard fine-grained acid granite close to the slate-granite contact.

Ilmenite.

Next in order of abundance of the dark minerals commonly occurring with tinstone concentrates are the iron sands, here consisting mainly of the mineral Ilmenite. This iron-black substance, the composition of which is oxide of iron and titanium, is known to miners under the name of titaniferous iron ore, whilst mineralogists occasionally use the synonym Menaccanite in referring to it. At times this mineral possesses a dark violet colour in sunlight. Its specific gravity—4·5 to 5—renders it less readily amenable to treatment in the sluicing box than tourmaline, but no real difficulty is usually experienced by skilled alluvial miners in eliminating practically the whole of the ilmenite by streaming methods, whilst it is readily got rid of in the Willoughby machine. I am informed by Mr. Brickwood that ilmenite is very commonly present in all the parcels of tin purchased by him from this field. The owner of the Erin-go-Bragh alluvial claim, on Nolan's Gully, Rossville, informs me that in the area downstream from his present working face, the mineral ilmenite frequently comprised as much as 5 per cent. of the total bulk of the tinstone concentrates obtained. It is also rather abundant at most of the alluvial claims at the Tableland.

Unfortunately, the number of Willoughby machines in this district for cleaning the tin concentrates is very limited, and many of those miners working their own small claims are compelled to adopt the rather expensive course of roughly streaming their tin concentrates to a payable marketable commodity in the first instance, and then continue accumulating the balance of the rejected richly stanniferous concentrates until they have sufficient to warrant carting it away to the nearest machine in order to obtain the remainder of the tinstone; seeing, however, that in the case of a large number of these instances the claims can only be reached by pack teams whose charges are necessarily high, it rarely proves a paying proposition to so transport the concentrates. The difficulty could, however, largely be overcome by groups of these small claims, which have to contend with much ilmenite and other dense impurities in their concentrates, combining to purchase machines for their common use. The cost of transporting the tinstone from the outlying hilly portions of the field makes it practically compulsory for the miners to send only high-grade tin concentrates to Cooktown.

Magnetite.

Of the remaining iron sands found occurring in this area, magnetic iron ore (magnetite) is the only one present in any

quantity at all, and, even then, in no great proportion anywhere; its removal is readily effected by spreading the dry tin concentrates out on a sheet and passing an ordinary magnet over it, when the little black grains of magnetite will immediately attach themselves to the magnet.

Hæmatite.

Another iron mineral present at times, in usually negligible quantity, is the variety of hematite (iron oxide) known as *specular iron ore*; this mineral has a silvery appearance, much like that of mica.

Monazite.

Of the light-coloured minerals possessing a sufficiently high specific gravity to remain behind with the tin concentrates during streaming, the rare-earth mineral monazite is perhaps the sole representative present; its specific gravity is relatively high for a light-coloured mineral, averaging about 5, but the quantity present with the tin is too small to warrant removal specially.

Scheelite.

A little scheelite (tungstate of lime) has been seen by me in the form of small yellowish to white grains in the tin from both the Romeo and Wallaby Creek branches of the Annan.

Topaz.

Topaz has been reported on rare occasions in the Wallaby Creek stanniferous alluvials, also at Lower Tableland (Four-mile Gully), but it may be said to be practically absent from the Cooktown tinfields—at least in the areas mined up to the present, in this respect differing markedly from the Stanthorpe tinfields, where the gem has a rather wide distribution.

CHAPTER III.

METEOROLOGY.

Cooktown being situated as far north as latitude 15° 27′ south, its climate would ordinarily be expected to exhibit the same characteristics of heat and humidity as are seen in the cases of Cairns and Townsville, lying within the tropics a short distance southwards, but I was agreeably surprised to find that Cooktown possesses a climate certainly no more trying than that of Brisbane.

During the spring and summer months there is a practically unceasing wind, which, combined with the nearness to the ocean, on the one hand, and the elevated country immediately behind the town on the other, results in a much cooler atmosphere than would otherwise be the case.

A perusal of attached Table A, kindly supplied by the Commonwealth Meteorologist, shows the average annual shade temperature experienced here over a period of fifteen years is only 78·3 deg., the hottest months in order of degrees being December, January, February, March, and November, whilst July, August, June, September, May, October, and April (in that order) are the coolest.

TABLE A.—MEAN TEMPERATURE* AT COOKTOWN.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1889	83·6	83·0	84·1	81·1	78·5	76·5	73·3	74·9	78·1	80·4	81·7	82·5	79·8
1890	81·9	81·8	82·3	78·5	76 8	74·7	72·0	74·4	77·7	79·1	79·6	82·3	78·4
1891	82·2	79·7	82·0	79·0	76·3	69·2	70·9	72·6	73·0	77·4	80·6	83·5	77·2
1892	82·8	81·4	81·3	80·5	77·8	75·8	72·3	74·9	76·2	79·8	81·0	82·5	78·9
1893	83·5	82·3	80·3	81·6	79·6	75·0	74·3	73·7	77·1	81·1	82·2	82·1	79·4
1894	82·7	81·3	80·4	80·8	76·6	73·7	72·6	75·8	76·3	79·2	79·8	80·4	78·5
1895	81·7	81·6	81·2	78·2	76·7	73·1	71·7	73·4	75·1	78·1	79·3	83·3	77·8
1896	82·2	82·2	81·2	80·7	75·2	72·7	71·9	71·4	74·9	77·5	80·8	83·3	77·8
1907	..	..	..	..	..	..	..	..	..	..	..	..	..
1908	80·6	82·5	81·6	79·8	77·3	72·0	72·2	74·0	76·2	78·5	79·8	82·1	78·1
1909	..	..	..	..	..	..	..	..	..	..	..	..	..
1910	81·7	81·0	80·6	78·4	76·6	73·9	74·1	75·4	76·9	80·0	81·4	83·2	78·6
1911	81·0	80·4	78·1	77·9	76·9	72·9	71·6	72·5	76·5	79·0	81·2	84·4	77·7
1912	83·4	81·9	80·4	79·8	76·4	76·5	73·6	73·1	77·2	79·4	82·8	82·6	78·8
1913	81·1	80·3	80·3	79·0	74·5	72·9	71·9	72·6	75·4	77·7	81·6	82·1	77·5
Average 13 years	82·2	81·5	81·1	79·6	76·9	73·8	72·5	73·7	76·2	79·0	80·9	82·6	78·3

* Computed from Mean Maxima and Mean Minima values:—Max. + Min.

On the tinfields, which are for the most part in elevated country, the climate is noticeably cooler than in Cooktown. Blankets were in use at Rossville during my visit there in the middle of summer, whilst at Tableland, Finnegan's, Grasstree, Mount Hartley, Granite Creek, and other places a fire is necessary for comfort during several months in the year, particularly during July and August.

Closely associated with temperature, considered in relation to the personal comfort of residents, and the ability to carry out laborious work within the tropics, is the important factor of humidity. The appended Table B, showing the average mean humidity at Cooktown (read at 9 o'clock in the morning), indicates that the point of saturation is most closely approached during the months of February and March (78 per cent.), whilst the air is driest during the months of October, November and December.

Rainfall records have been kept at Cooktown since the year 1874. Particulars of the falls during each individual month of the year, as also the annual totals, &c., will be seen on the accompanying Table C.

The wettest year recorded was 1903, when over 123 in. fell, whilst the year 1902 gave only 36 in.‡

The average rainfall for thirty-nine years has been about 73½ in., March and January being the wettest months, and September by far the driest in the year.

TABLE B.—MEAN HUMIDITY AT 9 A.M.* AT COOKTOWN.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1889	68	77	73	80	78	76	73	77	71	67	75	68	74
1890	61	76	73	74	73	74	72	68	66	63	54	63	68
1891	72	78	69	71	75	72	65	68	63	65	62	59	63
1892	..	66	77	67	70	73	69	68	64	64	61	62	67
1893	66	79	74	71	69	70	70	71	66	64	66	65	69
1894	77	76	79	79	72	73	67	68	63	62	70	71	71
1895	74	76	72	72	69	71	68	65	62	59	58	70	68
1896	79	82	80	75	70	72	72	70	63	64	70	68	72
1908	84	83	85	79	76	74	81	80	78	76	69	65	78
1910	80	80	81	76	78	79	78	73	75	74	74	72	77
1911	..	80	80	78	73	69	72	69	66	71	76	69	73
1912	76	77	81	74	70	83	75	70	73	62	68	61	73
1913	81	84	85	81	78	78	75	71	68	68	66	73	76
Average 13 years	74†	78	78	75	73	74	72	71	68	66	67	67	71

* Percentage of relative Humidity, Saturation = 100. † 11 years.

‡ It will be remembered that 1902 was the year of the great drought all over Australia.

A much greater rainfall is recorded on the tinfields than is the case at Cooktown, as the following figures for the year 1914 indicate:—

Rossville	128·92	inches
Mount Hartley ..	221	inches to 3rd December*
Lode Hill	127	inches.†

* The rainfall at Mount Hartley for the years 1912 and 1913 was 181 and 119 inches respectively.
† Details of the monthly falls at Lode Hill have already been given elsewhere under the heading of Lode Hill Tin Mines.

It must be remembered, however, that the year 1914 just passed was one of the wettest experienced for several years past—twenty-six years in the case of Lode Hill. The amount of rain falling over the tinfields is very closely bound up with the success or otherwise of tin mining there, water being used for both breaking down the alluvial and also for obtaining the tinstone at practically all the claims. There is usually only eight months' (November to June inclusive) efficient water supply in the case of the majority of the mines in this district.

TABLE C.—RAINFALL* AT COOKTOWN.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Total.
	Pts.	Pts.	Pts.	Pts.	Pts.	Pts.	Pts.	Pts.	Pts.	Pts.	Pts.	Pts.	Pts.
1874 ..	2,005	1,555	758	2,409	34	28	197	21	5	240	350	1,505	9,107
1875 ..	..	..	..	..	..	..	..	..	..	..	..	..	8,212†
1876 ..	1,478	2,660	1,459	366	571	0	0	0	0	0	30	1,006	7,570
1877 ..	..	..	..	..	..	..	..	..	..	..	..	..	6,315†
1878 ..	1,117	573	1,338	525	598	32	98	170	98	83	53	283	4,968
1879 ..	2,232	1,780	1,727	1,588	205	59	146	470	8	109	105	259	8,688
1880 ..	5,076	1,447	1,030	1,369	179	34	81	200	123	132	779	152	10,602
1881 ..	457	2,481	4,220	564	397	165	237	155	0	1	131	169	8,977
1882 ..	1,202	1,486	735	696	550	159	68	43	99	450	289	226	6,003
1883 ..	515	867	647	2,657	119	250	127	185	0	16	96	969	6,448
1884 ..	72	4,659	3,043	331	327	163	86	21	114	110	250	247	9,423
1885 ..	741	713	1,353	739	99	252	143	351	53	60	240	1,525	6,269
1886 ..	932	2,273	2,469	380	132	879	114	44	76	532	760	2,458	11,049
1887 ..	669	590	2,899	1,087	183	41	46	38	0	136	163	1,687	7,539
1888 ..	1,353	896	642	860	215	239	55	7	16	3	5	572	4,863
1889 ..	148	1,108	553	766	457	21	23	115	0	124	1,352	1,003	5,670
1890 ..	2,185	891	1,137	1,086	447	189	13	35	219	36	159	35	6,432
1891 ..	1,021	3,008	650	1,279	334	10	153	137	101	151	31	82	6,957
1892 ..	1,741	593	1,341	373	252	156	199	24	0	273	100	346	5,308
1893 ..	1,304	1,610	1,075	234	107	45	129	184	78	17	383	66	5,232
1894 ..	1,544	2,148	3,171	1,529	115	147	46	190	64	25	1,636	960	11,575
1895 ..	1,022	1,112	797	1,784	268	207	45	29	0	76	48	134	5,522
1896 ..	1,827	1,978	1,205	1,504	321	0	13	295	62	0	103	154	7,462
1897 ..	1,016	1,088	485	207	50	512	157	102	64	14	95	620	4,410
1898 ..	1,103	1,528	2,355	757	78	129	17	343	2	24	90	307	6,730
1899 ..	969	414	2,746	749	174	26	278	65	129	75	10	200	5,835
1900 ..	2,477	106	519	388	183	193	35	191	26	43	103	178	4,442
1901 ..	854	1,862	1,210	889	667	115	61	158	36	86	229	125	6,292
1902 ..	964	860	467	369	119	453	134	109	20	19	45	54	3,613
1903 ..	3,968	923	3,344	1,726	352	141	72	77	53	103	569	987	12,315
1904 ..	403	488	1,510	1,793	253	2	79	82	201	4	23	961	5,799
1905 ..	1,897	680	459	859	469	390	87	166	0	3	29	89	5,128
1906 ..	358	1,509	902	225	263	730	88	241	83	27	1,666	607	6,699
1907 ..	3,090	979	569	210	881	384	45	49	125	136	237	3,101	9,806
1908 ..	1,564	1,292	2,283	975	159	73	109	183	85	130	152	115	7,120
1909 ..	1,370	433	1,947	348	33	340	174	219	13	309	755	1,111	7,052
1910 ..	2,263	1,566	1,297	807	445	207	16	180	98	179	207	888	8,153
1911 ..	2,649	1,814	2,202	2,679	253	43	73	53	0	26	107	146	1,045
1912 ..	750	838	2,449	106	245	603	80	170	19	269	160	168	5,857
1913 ..	2,643	1,867	2,730	685	572	64	104	3	49	260	0	1,656	10,633
1914 ..	3,393	1,712	1,576	1,329	637	721	90	722	125	86	281	650	11,312
Mean, 39 years	1,551	1,394	1,572	952	301	210	93	149	58	112	303	662	7,357

* 100 points = 1 inch of rain. † Not included in means.

CHAPTER IV.

AGRICULTURE AND FORESTRY.

Whilst agriculture is practically at a standstill at present in the Cooktown district, owing largely to the absence of proper facilities for the despatch of fruit and other products, and also to the limited local consumption due to lack of population, there can be no doubt whatever but that this region, containing such splendid streams and favoured by Nature with excellent soil and rainfall, is destined in the future to become a centre of considerable production of tropical fruits, &c.

Peanuts are cultivated successfully on a moderate scale in the Cooktown district and are said to be proving a paying venture to those raising them. A large trade is carried on, mainly by Chinese, in the shipment southwards of mangoes; this fruit, which grows splendidly here, could be readily cultivated in enormous quantities all over the district if a sufficient market could be obtained to absorb the output, but at present the trade consists largely in the despatch of the fruit in its unripe state, the result being that it fails to bring good prices in the southern fruit shops when retailed.

Citrus trees of all kinds flourish here, the oranges, mandarins, lemons, &c., grown in the Cooktown region being amongst the best seen anywhere in the Commonwealth, both as regards size and flavour. Passion fruit abounds on the tinfields, and may be seen growing luxuriantly and producing fruit of the highest quality even in the uncultivated state through most of the scrubs, notably at Mount Hartley, Mount Amos, Finnegan's, &c. Papaws, bananas, pineapples, soursops, five-corners, li-chees, mulberries, and granadillas grow well in this district, whilst small groves of cocoanut trees in bearing can be seen at Cooktown, Eight Mile, Bloomfield River, and other places. Taro, yams, manioc, sweet potatoes, coffee, jack fruit, custard apples, and other tropical products are grown to a limited extent. An attempt to grow both sugar and tobacco on a large scale at the Bloomfield River near Ayton some years ago at the Plantation ended in failure, the former growing luxuriantly but with too low a density to be commercially valuable.

I am unaware of any mining field in Australia where the miners can so easily provide themselves with an abundance of

home-grown fruit and vegetables, and it is surprising that so many of the camps are without the small plot of cultivated ground requisite to supply their needs in this important respect. A pest that would have to be reckoned with by fruitgrowers is the flying-fox, this animal appearing in great clouds during the fruit season.

With regard to the exploitation of the timber resources of the tinfields, practically nothing of any extent has been done so far except to supply the limited local mining requirements. The Annan River Company's sawmill at their mine at Rossville was erected by the company for the purpose of supplying the timber required for the erection of their mine constructional work, the timbers being cut comprising several varieties of oak,* pencil cedar, hickory, scrub ironbark, sovereign wood, teak, &c. The timber locally known as maple is a variety of pencil cedar; this timber, which lasts well for mining purposes, is liable to split easily, hence holes should first be bored before nails are driven into it; it is difficult to burn. Yellow pine is durable, but the trees are usually rather small in size. Bean tree, candlenut, beefwood, &c., are abundant. "Kauri" pine grows to giant size at times but does not last well; when used in flumings it breaks easily on the waterline; it is fairly abundant in the scrubs. A fair quantity of red cedar occurs in places through the scrubs, whilst in the forest country a notable wood seen is that extraordinarily hard timber well named "ironwood"; the latter is much in demand by the aboriginals for the manufacture of their womerahs and other implements requiring the use of the hardest obtainable timber.

Should mining ever attain sufficiently great proportions to warrant the inauguration of tramway communication between the tinfields and the port of Cooktown, a considerable trade would undoubtedly be developed in the export of several of the valuable timbers growing in the scrubs. At the Kimberley Claim, Mount Romeo, the 50-ft. high flume over Baird's Creek is constructed of bloodwood uprights with pencil cedar fluming. Kauri pine was used for the flumes, but this timber lasted only one season and had to be replaced by pencil cedar. At Lode Hill Mine, China Camp district, the timber required for mining purposes is carried by aboriginals on their backs for a distance of about 3 miles, the varieties so transported including maple, silky oak, black oak, and red oak. I understand from the mine manager that the contract price for this timber delivered at the mine is £2 15s. per 100 super. ft.

* The names listed herein are those applied locally to the various timbers, and do not necessarily refer to similarly designated trees elsewhere.

At Shipton's Flat red cedar has been found the most satisfactory timber available for the races, particularly in the flumings, but fern-top or acacia cedar is used almost exclusively in the construction of the sluice boxes.

When the price is sufficiently high a good trade is done with the Chinese merchants in Cooktown in the business of sandalwood getting; the high price obtaining for this commodity in the early part of 1914 absorbed a certain number of tin prospectors until the price fell below what was considered payable.

In localities where the scrubs have been cut down—*e.g.*, along abandoned timber tracks, &c., the stinging-nettle usually makes its unwelcome appearance in great abundance; the merest brush on the skin from the leaves of this plant causes severe pain, which lasts for several days and recurs at times for several months, especially on wetting the part stung; when horses are severely stung by this plant they generally become insane and destroy themselves. Another plant which has frequently caused pain to the unwary is that growing in the scrubs and known as the "burning vine." This latter produces a distinct sensation similar to that caused by touching a piece of hot wire, but fortunately the effects rapidly disappear permanently.

A great variety and abundance of berries, nuts, native plums, &c., grow in the scrubs; many of these are eaten by the blacks but they taste very "woody." Immense flocks of Torres Straits pigeons visit the scrubs at certain times of the year, whilst several other varieties of pigeons, as also scrub turkeys, are abundant. Wild pigs are found in all the scrub areas, the advent of these animals having resulted in a great diminution in the scrub turkeys and snakes. The snakes comprise carpet snakes (often of giant size), brown, black, water, scrub, and whip snakes, &c. In the mountainous areas, notably at Mount Finlayson, that rare marsupial, the tree-climbing kangaroo, may still be found, though this interesting animal is unfortunately rapidly dying out. The scrubs are also the home of great numbers of white-tailed rats, to resist the depredations of which rodents the miners have to adopt special measures for the safety of their provisions.

Another troublesome pest in the scrubs—particularly in the wet season—is the countless myriads of leeches which are found there. In order to overcome this little blood-sucker the miners usually rub a thick layer of soap on their boots; it has been found that when a leech attaches itself to one's skin, the best method to pursue is not to remove it instantly but to allow

it to take its fill of blood, when it will drop off of its own accord; if removed quickly after they have punctured the skin a very irritating itchiness, much like that caused by sandfly bites, quickly ensues.

The practical absence of mosquitoes from the tinfields is rather remarkable, considering the latitude, rainfall, &c., of this region. The curious cat-bird, the hammer-bird, and other members of the feathered tribe of nocturnal habits, produce extremely weird noises in the scrubs after sundown. When the scrubs are cleared there usually springs up a very succulent grass known as scrub grass, which is excellent stock feed, but in the open forest country the commonest grass is the nearly useless bladey grass; in order to make green feed the miners burn off the bladey grass as soon as it becomes dry enough to burn, when it will spring up again and produce a limited amount of green feed for stock after rain has fallen. In the centres of scrub areas one frequently comes across a circular area of grassy forest country; these areas are known as "pockets" and form excellent grazing grounds for horses, a slip-rail across the tracks leading into them from the scrub sufficing to keep the horses as securely as though the area were fenced.

As usual in the case of mining fields all over Australia, flocks of goats roam the tinfields here, though they do not appear to flourish so well as in other places, this being due partly to the presence of certain poison bushes, including the small shrub with white petal-like leaves known locally as ironwood and abundant in the forest country between Rossville and Helenvale. A magnificent variety of palms and tree ferns abound through the scrub areas, as also of orchids, lycopodiums, and flowering shrubs.

Alligators have been seen in the Annan River to a point upstream at least as far as the junction of Trevethan Creek, whilst the lower course of the river through the mangrove-covered swamps in the vicinity of the Annan Bridge, 5 miles from Cooktown, is known to be badly infested with these reptiles; a nest of alligator eggs is recorded as being found even as far upstream as Helenvale some years ago.

CHAPTER V.

STATISTICS.

In his Annual Report for the year 1914 Mr. Warden Power states:—"The average value of the tin oxide produced for the year was not so good by about £29 per ton. Although the highest price was reached this year when it brought £2 2s. 6d. per unit, the price dropped very considerably towards the middle of the year, and at the outbreak of war was down to £1 4s. per unit; then the market reopened in December at £1 3s. and gradually rose to £1 4s. 6d. per unit. It is quite likely that many tin miners are holding their produce back since the first serious fall in prices; this of course will go into the next year's returns."

The output of tin for the year 1914 is given by the Warden as follows:—

	Tons	cwt.	qr.	lb.	Value. £	s.	d.
Lode tin	8	14	3	9	758	19	0
Alluvial tin ..	214	9	1	23	21,575	10	8
Totals ..	223	4	1	4	£22,334	9	8

As will be seen by Table D, showing the annual yields, the years 1887 to 1895 were responsible for by far the highest returns recorded, whereas the period 1896 to 1907 were the years of greatest depression; since 1907 the returns have been fairly regular, the average annual output for the last seven years having been about 252 tons; it can with confidence be predicted that the extensive operations of the Annan River Company will substantially increase this average during the present (1915) and subsequent years.

TABLE D.—ANNUAL YIELD AND ESTIMATED VALUE OF TIN ORE WON IN THE COOKTOWN DISTRICT FOR THE YEARS 1885 TO 1914, INCLUSIVE.*

Year	Tin Ore in Tons. (2,240 lb.)	Estimated Value. £	Year.	Tin Ore in Tons. (2,240 lb.)	Estimated Value. £
1885 ..	300	3,144	1901 ..	158	9,327
1886 ..	143	7,400	1902 ..	105	7,904
1887 ..	945	58,783	1903 ..	177	13,706
1888 ..	1,051	66,949	1904 ..	147	11,456
1889 ..	690	38,000	1905 ..	142	12,463
1890 ..	578	34,979	1906 ..	165	18,836
1891 ..	472	27,094	1907 ..	181	19,614
1892 ..	421	24,000	1908 ..	235	19,037
1893 ..	347	17,278	1909 ..	248	21,068
1894 ..	438	18,834	1910 ..	296	28,378
1895	419	16,196	1911 ..	196	22,559
1896	257	9,568	1912 ..	272	36,233
1897 ..	146	5,335	1913 ..	293	38,065
1898 ..	145	5,927	1914 ..	223	22,334
1899 ..	166	12,031			
1900 ..	159	12,417	Totals ..	9,520	£638,915

* These figures do not include the tin won on the Palmer Field.

According to the Warden's report, the figures in Table E represent the population of the Cooktown Tinfields for 1914.

TABLE E.—RETURN OF ESTIMATED POPULATION FOR 1914.

LOCALITY.	EUROPEAN.						ASIATIC.			GRAND TOTAL.
	MINERS.		Carters, Timbergetters, Attendants, &c.	Merchants and Tradesmen.	Women and Children.	Total.	Alluvial Miners.	Storekeepers, Gardeners, &c.	Total.	
	Quartz.	Alluvial.								
Cooktown Field.										
Rossville	...	79	24	40	74	217	...	2	2	219
Bloomfield		26	8	16	24	74	...	...	...	74
China Camp ...	...	26	6	4	9	45	...	...	...	45
Mount Amos	6	26	3	4	35	74	...	...	...	74
Mount Hartley	...	13	...	...	5	18	...	...	...	18
Mount Romeo	...	20	4	2	13	39	...	...	...	39
Grasstree	...	10	4	...	20	34	...	...	...	34
Shipton's	...	46	5	...	43	94	...	...	...	94
Mount Poverty	...	4	2	...	6	12	...	...	...	12
Tableland	...	8	...	...	2	10	...	...	...	10
Totals	6	258	56	66	231	617	...	2	2	619
Palmer Field.										
Mount Windsor	...	9	...	...	1	10	16	...	16	26
Granite Creek	...	...	...	...	...	...	55	7	62	62
Cannibal Creek	3	...	...	...	...	3	12	1	13	16
Totals	3	9	...	...	1	13	83	8	91	104
Bowden Field.										
Pascoe River	3	...	...	...	...	3	...	...	...	3
Tin Creek	...	7	...	...	...	7	...	...	...	7
Totals	3		...	...	...	10	...	...	...	10

With regard to the world's production and price of tin during the year 1914, the following excerpt should be of interest* :—

"Though tin, unlike copper, did not fall so low as it has done in the previous ten years, there was at times no market, and consequently it is almost meaningless to say that £118 or thereabouts was the lowest figure touched. Generally speaking, the price was a declining one from February onward, until the bottom fell entirely out of the market on the outbreak of war. From the reopening of the Metal Exchange on 29th October there was a steady improvement, and the year closed at £146 10s., as compared with £168 5s. for the beginning of the year. The depression in tin mining began to be felt toward the end of 1913, and consequently when the war broke out production was already on a somewhat reduced scale. Tin mining is a very

* "Mining Journal," London, 23rd January, 1915.

scattered industry, and it is supported by no large financial interests such as play an active part in copper, spelter, and lead. With the sudden disappearance of markets a general closing down was so obviously imminent that various interests intervened in different parts of the world to mitigate the loss which threatened tin miners generally if the mines had to close down. The effect of these measures has undoubtedly been to enhance production greatly above what it would have been had economic forces been allowed to operate without interference.

* * * * * * * *

As regards consumption, it is difficult to speak. It stands to reason that it has been seriously affected, but all considerations suggest the conclusion less so than production. The English tinplate output was less last year, exports being 59,000 tons lower. On the other hand, the American production is estimated at 75,000 tons more than in 1913. Consequently, it is necessary to consider only possible declines in German, Italian, and other Continental makes of tinplate, which are not likely in the gross to amount to very much. Probably there was little or no decline in the consumption of tinplate last year. The other commercial uses of tin were, of course, affected by the check on the activity of trade all over the world caused by the approach of the war and by the shock which its outbreak gave. Against that, however, is to be set the enhanced demand due to special requirements of the war, and if one can judge by the activity of tin exports, these requirements are very extensive. The total deliveries in tin in America last year are given as 41,700 tons, compared with 43,900 tons in 1913—a decline, that is, of 2,200 tons. As America is generally assumed to be responsible for about two-fifths of the world's requirements, we might calculate on this basis that the world's consumption declined last year by something like 5,500 tons, as compared with a decrease in production, which, allowing for the increase in Banka stocks, stands on the foregoing figures at about 12,000 tons. Such a figure, representing a decline in stocks of over 6,000 tons, cannot be ignored, and is in itself an assurance of better times to come. What is impossible to judge is how far the declines, especially in the case of Bolivia and Banka, are due to temporary and accidental rather than to more enduring causes, and are already giving place to resumption of supplies in normal quantities. There can be no doubt that there is at present a great shortage of immediate stocks. Part of this is, of course, due to the fact that you cannot carry on business in a period of world-wide war with the same small margin of stocks that is practicable in peace

time, but the excess in shipments from England over the receipts and internal consumption toward the end of the year indicate the using up of invisible stocks to a considerable extent."

* * * * * * * *

The appended table shows the average monthly price of tin in London for the thirteen-year period 1902 to 1914 inclusive, the figures given being taken from the report of the German institution known as the Metallgesellschaft, Frankfurt-am-Main.

AVERAGE MONTHLY PRICE OF TIN IN LONDON (IN POUNDS STERLING PER TON OF 2,240 LB.)

Year.	Jan.	Feb.	Mar.	April.	May.	June	July.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1902 ..	105 6 5	114 4 9	115 10 6	125 14 2	134 13 10	129 12 10	127 3 2
1903 ..	127 12 6	133 8 1	137 0 6	136 19 2	133 12 0	127 11 0	125 1 7
1904 ..	130 10 4	125 13 6	126 9 8	127 5 1	125 7 2	119 11 1	119 18 6
1905 ..	131 5 11	131 3 6	134 17 2	140 11 8	136 11 8	138 3 6	144 6 8
1906 ..	164 11 10	166 0 10	166 1 2	176 14 5	192 6 4	178 0 7	170 12 5
1907 ..	190 4 0	191 18 9	188 17 6	187 1 2	191 1 10	187 10 11	188 0 2
1908 ..	128 9 0	128 14 1	137 19 8	143 12 10	135 11 6	127 12 2	131 6 10
1909 ..	127 7 3	127 15 3	130 6 7	133 8 3	131 16 10	133 4 0	131 19 1
1910 ..	148 3 6	149 13 0	147 4 11	149 19 3	150 1 8	148 13 1	149 2 1
1911 ..	187 17 11	189 12 10	182 12 4	193 0 10	197 15 4	207 7 9	193 2 0
1912 ..	191 14 0	195 4 10	192 15 0	200 8 3	209 6 1	205 18 9	202 8 3
1913 ..	238 5 6	220 2 10	213 12 4	224 3 2	224 2 10	207 4 2	183 10 3
1914 ..	171 18 1	181 11 1	173 12 4	163 19 3	150 14 4	138 6 5	142 10 4

Year.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1902 ..	126 10 0	121 10 7	117 11 3	115 2 3	115 13 5	1902 120 14 5
1903 ..	127 16 10	120 9 6	115 17 1	116 13 9	125 15 0	1903 127 6 5
1904 ..	122 5 9	126 7 7	130 11 6	133 0 5	133 15 6	1904 126 14 8
1905 ..	150 5 6	146 11 9	148 3 6	152 5 3	162 14 3	1905 143 1 8
1906 ..	180 19 11	184 15 3	195 15 11	195 15 10	195 19 9	1906 180 12 11
1907 ..	170 5 9	166 6 6	146 7 7	138 8 8	125 10 4	1907 172 12 9
1908 ..	134 16 2	131 6 8	133 8 8	137 8 3	132 4 7	1908 133 2 6
1909 ..	135 18 3	137 14 6	138 13 2	140 0 3	149 2 3	1909 134 15 6
1910 ..	155 8 2	160 8 7	164 4 9	166 18 0	173 17 3	1910 156 6 2
1911 ..	190 9 7	180 16 11	187 2 9	194 19 4	203 7 2	1911 192 7 0½
1912 ..	208 3 0	223 19 6	228 9 1	227 16 10	226 17 8	1912 209 8 5
1913 ..	188 14 7	193 1 6	184 16 9	180 17 5	171 15 9	1913 206 5 7
1914 ..	(c)	(c)	(c)	139 7 10	147 2 4	1914 ..

(a) As reported by *Metallgesellschaft, Frankfurt-am-Main.*
(b) As reported by "The Mining Journal" (London).
(c) No quotations.

The following statement concerning the world's production and consumption of tin is taken from the "Mineral Industry During 1914."*

"The normal yearly output of tin throughout the world is in round figures 125,000 tons, as compared with 100,000 tons ten years ago. The increase is distributed among all the producing countries with the exception of Australia. The greatest increase is shown by Bolivia, a country that promises still further expansion. The output of the Malay Peninsula, commonly called "Straits" tin, is about 63,000 tons per year, of Bolivia 20,000 tons, the Dutch East Indies 17,000 tons, Cornwall 5,000 tons, Australia 5,000 tons, South Africa 2,600 tons, and Nigeria 4,500 tons. The only figures available for China are those of export, which averages 6,000 tons, but large quantities must also be used locally. Smaller amounts are produced in Germany, France, North-western Spain, Portugal, Mexico, and Alaska. As regards the future, Nigeria is the only region besides Bolivia that promises an increase of output. It is too early to have accurate figures for the output of 1914, but judging by the periodical reports issued during the year, the total production will be about 120,000 tons."

PRODUCTION OF TIN METAL IN THE WORLD (IN METRIC TONS).

Country in which Smelted.	1909.	1910.	1911.	1912.	1913.	1914.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Australia (*m*) ..	6,450	5,500	5,150	5,130	4,870	(*e*) 1,550
Austria-Hungary (*a*)	52	39	16	14	13	..
Banka, sales in Holland (*m*)	12,150	13,631	15,147	16,111	15,173	..
Billiton, sales in Holland and Java (*m*)	2,280	2,240	2,240	2,243	2,243	..
Bolivia, metal exported to England (*w*)	834	1,003	464	552	(*e*) 390	..
China, exports (*a*) ..	4,516	6,510	6,056	8,785	3,889	(*e*) 2,000
France (*m*)	Nil	Nil	500	500	1,200	..
Germany, mainly from Bolivian ores (*a*)	8,995	11,394	12,426	10,646	(*m*) 11,500	..
Japan (*a*)	23	23	155	36	(*e*) 50	..
Straits Settlements, exports (*m*)	61,540	57,490	57,944	61,528	65,640	66,327
United Kingdom, from domestic ores (*a*)	5,282	4,874	4,950	(*m*) 5,338	(*m*) 5,300	(*e*) 5,000
United Kingdom, from imported ores (*m*)	11,890	13,055	13,850	13,600	16,700	..
Total Production of Metal	114,012	115,759	118,898	124,483	126,878	..

* "Mineral Industry During 1914"; volume XXIII., pp. 719 and 720.

(*a*) Official statistics. (*e*) Estimated. (*m*) *Metallgesellschaft.* (*w*) Watson and Co.

NOTE.—Among the more important omissions from the above table, due to imperfect statistics, are the following:—(1) Output of native smelters in Central and South Africa; (2) Exports from Siam and the Dutch East Indies to India, China, Korea, and Japan; (3) Local consumption in Straits Settlements, Siam, and Dutch East Indies.

CHAPTER VI.

Future Prospects of the Annan River Tinfield.

Whilst admitting that a preponderating quota of the 9,520 tons of tinstone officially recorded from the Cooktown tinfields, as having been won in the period that has elapsed since they were first opened some thirty years ago, represents stream tin obtained in the early days from the easily worked and frequently rich alluvial deposits along the present day stream channels, the future yields will, in my opinion, comprise very largely also the metal won from—

(*a*) The undoubtedly huge deposits occurring in the greisenised granite constituting the slate-granite contact zone;

(*b*) The extensive superficial deposits lying on hillsides below that zone;

(*c*) Terrace deposits above the present stream channels; and

(*d*) The dredging of areas of low-grade alluvial material existing along the Annan River and its numerous tributary streams.

With regard to the already more or less worked-out alluvial deposits along the present streams, it should be remembered that there still remain extensive areas—*e.g.*, Nunn's Forks, Bowditch's Flat, Mungumby Flat, Romeo Flat, Banana Flat, Shipton's Flat, Jackeroo, from Rossville eastward along Wallaby Creek to beyond Home Rule, &c., which would pay to work if cheap methods of dredging were introduced, but their successful exploitation by the old-fashioned hand methods is entirely out of the question.

As the scrubs are gradually invaded it is found that there frequently exists, on the hillslopes below the granite-slate contact zone, widespread superficial deposits of talus material, this detritus being usually sufficiently high in tin values to warrant being sluiced, providing that an efficient supply of water for this purpose is obtainable at a reasonable cost. Unfortunately, however, for the success of this form of mining in the immediate future, the mountainous nature of most of the area now under review, frequently necessitating the construction of costly flumes and pipe lines, as also the fact that practically all the really important water rights have long since been secured, the working of these deposits will probably have to remain in abeyance for

the most part until such time as the requisite water is available at a cost sufficiently low to warrant its being brought on to the areas in question.

Those claims possessing the advantage of an abundant water supply and a sufficiency of "fall" for sluicing purposes have, without exception, all adopted the very convenient method of hydraulicing, whereby the sluicing is carried out by nozzle pressure produced by a column of pipes of gradually diminishing size laid down steeply sloping ground, and, in this rugged area, with an abundant rainfall, it is highly improbable that any entirely different system of treating the alluvial will ever replace that at present in vogue here. Although the initial outlays involved in the construction of the head races to convey water by this gravitational method have often severly taxed the finances of those who, unaided, have undertaken these frequently herculean tasks, the Department of Mines has on several occasions timely come to their rescue with advances of money, the result being that many properties which, without this assistance, would probably never have been worked, are to-day paying handsome dividends to the men whose practical engineering ability foresaw the possibility of, and results to be obtained from, the undertaking.

The torrential falls of rain, which are a characteristic feature of the meteorology of this tropical region, would have to be seriously taken into consideration in connection with any future proposal to dredge the alluvial deposits along the main stream channels, floods, such as those commonly experienced, probably resulting in the dredging plants being swept away and the working faces buried deep in flood-borne material, unless sufficient protection in the shape of by-washes, earth walls, &c., be provided.

After the wet seasons it is found that a reconcentration of the loose alluvial along their beds and banks has usually been effected by the streams, producing small local deposits of tinstone at and near the surface; these deposits have afforded a living for miners for many years past, during the drier portions of the year when the streams are lowest, and will, doubtless, always continue to add a small amount of tin annually to the total yield from the field.

The tin-bearing lodes worked up to the present have not, as a rule, proved remunerative for any lengthy period; several attempts have been made to work these deposits, *e.g.*, at Lion's Den, Phœnician, Mount Amos, Mount Leswell, Collingwood, &c.,

but usually without any marked success. In my opinion, the lodes seen by me during the course of the present examination, are not of sufficient size to warrant the expenditure of any large sums upon them by companies, but, in many instances, are admirably suited to being worked by small parties of miners who would limit their operations to the picking out of the rich veins of ore traversing the lode formations.

By far the most important operations on the field are those being conducted by the Annan River Company, at Rossville, and Collingwood, where very extensive contact deposits have been located. The remarkable decomposition which has taken place in these stanniferous granites often permits of their being readily disintegrated to very considerable depths by water pressure, and it was for the purpose of ensuring an efficient water supply throughout the year that the company named have lately erected at Wallaby Creek, a powerful pumping plant, involving the outlay of many thousands of pounds. Whilst the ground already definitely proved here by boring, &c., to be stanniferous, undoubtedly does comprise an enormous yardage, the fact should not be lost sight of that these relatively low-grade deposits can be profitably exploited only by maintaining the working costs at a minimum, and to this end the use of the most up-to-date gas-explosion pumps, in order to reduce the high cost of firewood, appears to offer the best chance of success. The installation of systems of flying-foxes for the purpose of disposing of the large quantity of granite boulders met with during sluicing would materially assist in the cheap and rapid removal of these hindrances to sluicing.

There can be no doubt whatever but that many contact deposits, in addition to those described elsewhere in this report, will eventually be discovered along the slate-granite boundary, but it is only in the case of those extensive occurrences of this class which are sufficiently decomposed to allow of being sluiced will any quantity of metal be obtained in the future, the tin contents so far determined in these formations being altogether too low to permit of the material being payably treated by crushing mills.

It is rather improbable that any important workable deposits of metals other than those of tinstone will be found in the area mapped.

Reviewing the subject as a whole, I am strongly of opinion that the tinfields in the Cooktown district will, whilst rarely affording any sensationally rich yields, continue to maintain a steady output of metal for a very long period of years; the life

of this particular field must necessarily be very great, and the probability is that the average annual output of the last decade will be substantially augmented in the one now entered upon, when the following considerations, among others, are kept in view:—

(*a*) The great number and extent of the various deposits —notably those classed as "contact deposits"— already opened up;

(*b*) The stanniferous areas which have yet to be prospected in the scrubs;

(*c*) The relatively slow methods of work that are necessitated by the rugged nature of the country, the distribution and ownership of efficient sluicing supplies, &c.; and

(*d*) The usually low-grade character of the remaining easily worked alluvial deposits—the present average annual output being about 1 ton per miner in the case of small claims.

CHAPTER VII.

Tin Mining at China Camp, Bloomfield District, Cooktown.

China Camp is the name given locally to that portion of the Cooktown District tinfields situated near the Roaring Meg River, about 70 miles by road and 40 miles in a nearly direct

[*Photo., C. Francis.*

PLATE 42.—BLOOMFIELD FALLS, BLOOMFIELD RIVER, NEAR AYTON.

line south from Cooktown township. It includes the Lode Hill, Roaring Meg, etc., claims. The tidal portion of the Roaring Meg River is called the Bloomfield River, the first mentioned

name being assumed by the stream immediately above the Bloomfield Falls near the old mission station, a few miles up from the coast.

Above these falls the river consists in large part of a series of cataracts and waterfalls, the most important of these being the Roaring Meg Falls, from which the river takes its name. The falls referred to consist of extremely steep cascades, having a height of at least 200 ft., the escarpment over which the river pours consisting of a ridge of hard granite crossing the river

[*Photo., C. Francis.*

PLATE 43.—ROARING MEG FALLS, ROARING MEG, BLOOMFIELD RIVER, NEAR CHINA CAMP.

at right angles. A large quantity of water was running over the falls at the time of my visit, at the end of August, but, I am informed that in the wet season (December to March)

the river assumes magnificent proportions, the noise of the foaming water plunging over the falls being audible for miles. The stream takes its head near Peter Botte Mountain (3,311 feet above sea level).

This portion of the field is reached from Cooktown by a rough dray track (23 miles) as far as the Rossville turn-off at Nunn's Forks, about 2 miles past Helenvale and near the Junction of the Annan River and Wallaby Creek. Between Trevethan and Helenvale the road crosses the prominent ridge from Black Mountain at a height of approximately 500 ft. above sea level, and distant 16 miles from Cooktown. After leaving the Rossville road turn-off (350 ft. above sea level) the track is of the usual unformed character, but is negotiable as far as Grasstree (37 miles from Cooktown), where an elevation of 1,100 ft. is attained.

From Grasstree the track is quite impassable for vehicles as far as the foot of the range, being through dense lawyer vine, etc., scrub to the top of Stuckey's Gap (distant 41½ miles from Cooktown, altitude 1,250 ft.). The track down Stuckey's Gap is extremely steep, and consists of a succession of bare boulders of granite, over which it is by no means easy to lead a horse. From the foot of the range to the little settlement of Ayton, on the Bloomfield River (51 miles), the track is across practically level country through the area known as The Plantation.

From Ayton there is a bridle track some four miles in length through scrub country to The Crossing. At low tide it is possible to ride across the river at this point, but it is usually necessary to avail oneself of a rowing boat and swim the riding horses across, as the presence of alligators along this river renders wading or swimming far too unsafe to attempt. From the landing place on the right bank of the stream the track ascends by a steep grade to the top of the Zig Zag (600 ft. above sea level), and then traverses ridges to the Roaring Meg River Crossing (65 miles), the latter river constituting the upper portion of the Bloomfield River, as stated previously. This crossing is over rounded boulders and usually fairly deep, whilst in the wet season it is not safely negotiable owing to the volume and rapidity of flow of the stream. A distance of 4 miles from the river brings one to China Camp, at an elevation of 750 ft. at the Lode Hill workings.

Accommodation is obtainable *en route* at the Trevethan and Helenvale (Lion's Den) Hotels and at the Ayton accommodation house.

The principal mining operations being carried out here are those of the Lode Hill Company, a description of which is here furnished:—

LODE HILL TIN MINING COMPANY, NO LIABILITY.

John W. Northey, mining engineer, mine manager; C. E. Bradshaw, secretary; registered office of the company, 99 Queen street, Melbourne; attorney in Cooktown, Charles Patching, solicitor. I am informed by the manager that there are 100,000 shares in the company, called up to 3s. 3d. per share at the time of my visit.

[*Photo., W. Horsfield.*

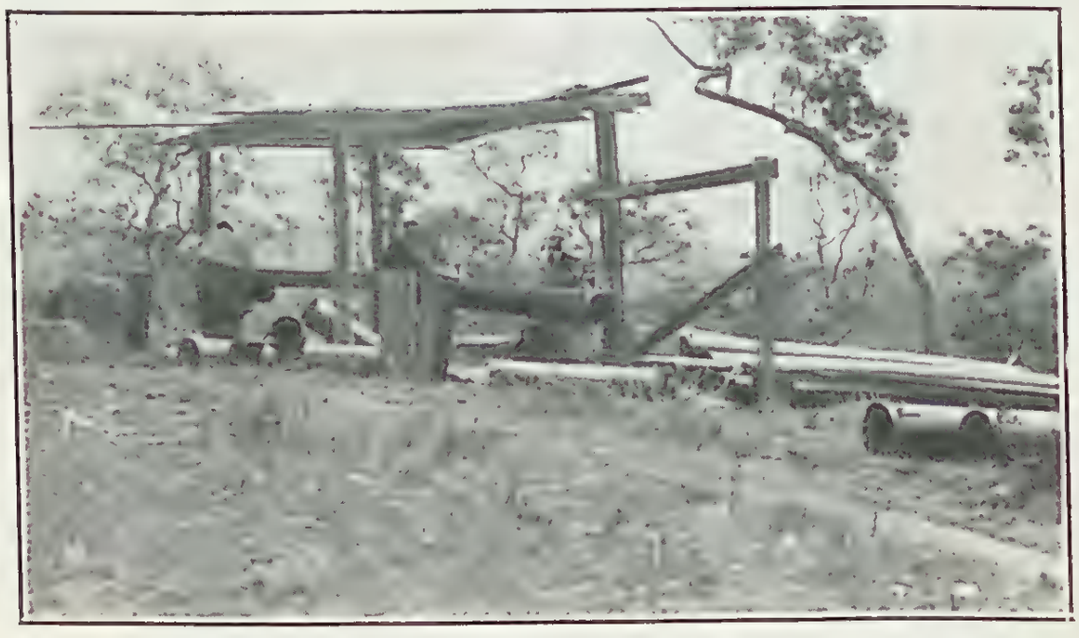
PLATE 44.—LODE HILL COMPANY'S HEAD RACE.

Elbow-fluming—an excellent piece of constructional work in dense vine scrub across a gully.

The deposit was discovered about the year 1908 by Mr. J. T. Elliott, and to that gentleman's dogged persistence and practical engineering ability is in the main due the existence of this property as a workable proposition. Seeing that it was essential to the working of the deposit that an efficient water supply be provided, he commenced, unaided, the herculean task of bringing a head race on to the property from the Bloomfield River, and after working for some two years, during which period he was joined by Mr. Skirving, he succeeded in bringing water on to the property. Messrs. Elliott and Skirving then sluiced an area to a shallow depth close to the slate-granite

contact, and obtained sufficient tin to prove the existence of an extensive deposit of treatable material. They then disposed of the property to the present company in June, 1913. Since the inception of mining operations about 300 tons of tinstone are stated by Mr. Northey to have been won on the area sluiced.

After taking possession of the property the company carried out a considerable amount of development work, including improvements to the head race and the construction of a tail race. The head race from the Bloomfield River to the workings consists of 2 miles 1 chain of earthwork and 33 chains of iron fluming. The size of the race is 4 ft. wide and 3 ft. deep. The "fall" allowed is 1½ in. per chain along the earthwork and 3 in. per chain along the fluming, the increased fall along the latter allowing for a smaller sized getaway for the water by reason of the swifter rate of flow. It is estimated that about seven million gallons of water are conveyed along this race in the twenty-four hours. From the point where the race crosses the dividing ridge between the Bloomfield River and Baird's Creek a head pressure of over 600 ft. is available at the workings. The water as supplied is quite clear and therefore ideally suited to sluicing operations.



[*Photo., C. Francis.*

PLATE 45.—LODE HILL CLAIM, CHINA CAMP.
Making riveted iron pipes at the mine.

The pipe column along which the water is conveyed at present from the lower end of the head race to the working face has a diameter of 11 in., but a larger (14 in.) diameter column is at present under construction at the mine and will soon be installed. The pipe column is made of 14-gauge black iron. The iron is procured in Melbourne, at which place it is cut into

3-ft. lengths and bored ready for riveting; it is then conveyed in flat sheets to Cooktown, at which latter place it is rolled into pipe shape, in which form it is conveyed by sailing boat to the Bloomfield River and thence packed on horses to the mine, where it is flanged, riveted, and finally completed. A very considerable saving in expense is effected in this way. From the dimensions and "fall" of the race and fluming it is at once apparent that many ground sluice-heads of water can be brought on to the face from the intake at the Bloomfield River.*

I am informed by the manager that the cost of 1,500 ft. of 14-in. pipe complete has been £510. The size of the nozzle is 11 in., with a tip of 4 in., and the pressure available with this apparatus is stated to be 230 ft., or 103 lb. per square inch. When the plant is operating on ground clear of boulders the capacity is approximately 100 cubic yards per hour. The total cost to date has worked out at 5d. per cubic yard, but the actual mining cost is given at about only 3d. per yard. Up to the date of my visit some 120,000 cubic yards of material had been sluiced for a yield of 50 tons of tinstone, whilst a further clean-up yet to be made of the ground already sluiced is estimated by the manager to add a further 15 to 20 tons of oxide from 40,000 cubic yards sluiced. The tinstone averages 71·2 per cent., the highest being 72·6 per cent.

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* The Regulations now in force in this State concerning water-rights thus define the much-debated question as to the quantities of water referred to under the names of box sluice-heads and ground sluice-heads, respectively:—

"Regulation 70. A *box sluice-head* shall be a body of water one inch by twelve inches.

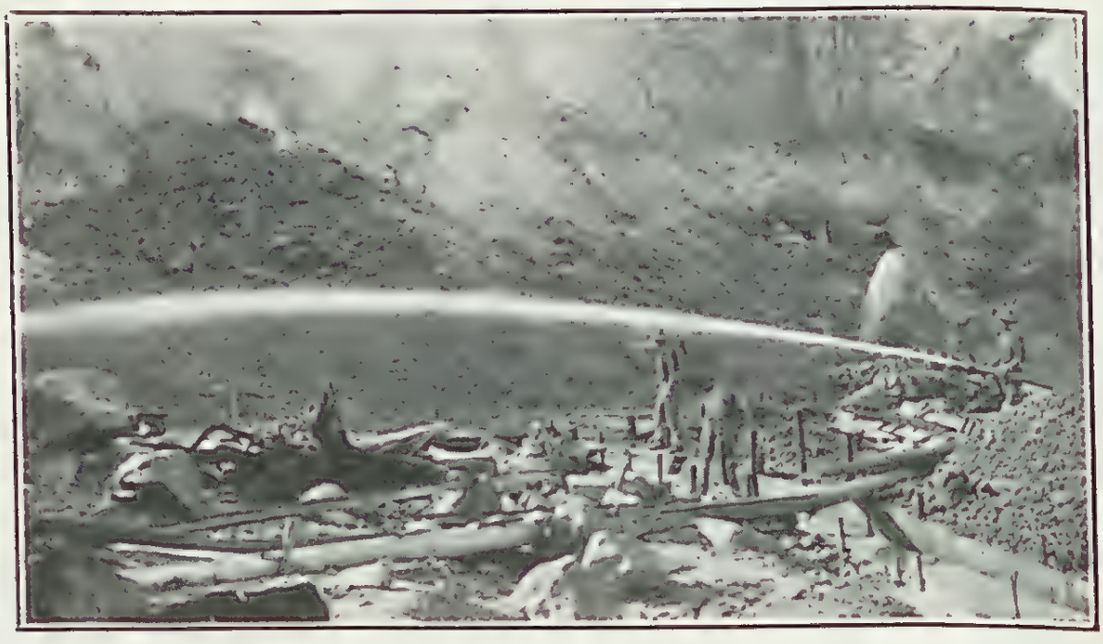
"A *ground sluice-head* shall be a body of water three inches by twelve inches, and shall be gauged in the following manner:—A box, six feet in length and twelve inches in width, with a scale of inches marked on the inner side at the lower end, shall be placed at the head of the race, having a fall not exceeding six inches in the entire length of it, and the gauge of water shall be taken at the mouth of the box where the water is discharged. When the length of the race exceeds one mile, the width of the box may be increased half an inch for each mile.

"It shall not be necessary to gauge any water being used except in pursuance of an order made by the Warden after hearing the evidence of any holders of miners' rights whose interest he finds have been or may be affected.

"Regulation 71. The quantity of water to which any person shall be entitled under one water-right for sluicing purposes on any claim shall not exceed two ground sluice-heads.

"In all river-beds from which water is diverted for mining purposes there shall be left running at least one ground sluice-head for general use when required."

For the removal of the material sluiced a tail race 24 chains in length and 7 ft. in width by 3 ft. 6 in. deep has been made; "fall" allowed, 5 in. in 12 ft. In addition there are 4 chains of the race 16 ft. 6 in. in width by 3 ft. in depth. This 4-chain section (situated at the head of the tail race and immediately below the main open-cut workings) is boarded on the sides and cemented on the bottom. The cement was made of 1 part of cement, 3 parts of sand, and 4 parts of stone. The "fall" here is also 5 in. per 12 ft., as in the case of the main tail race. Eleven ripples are in use, separating the box into 22-ft. bays.



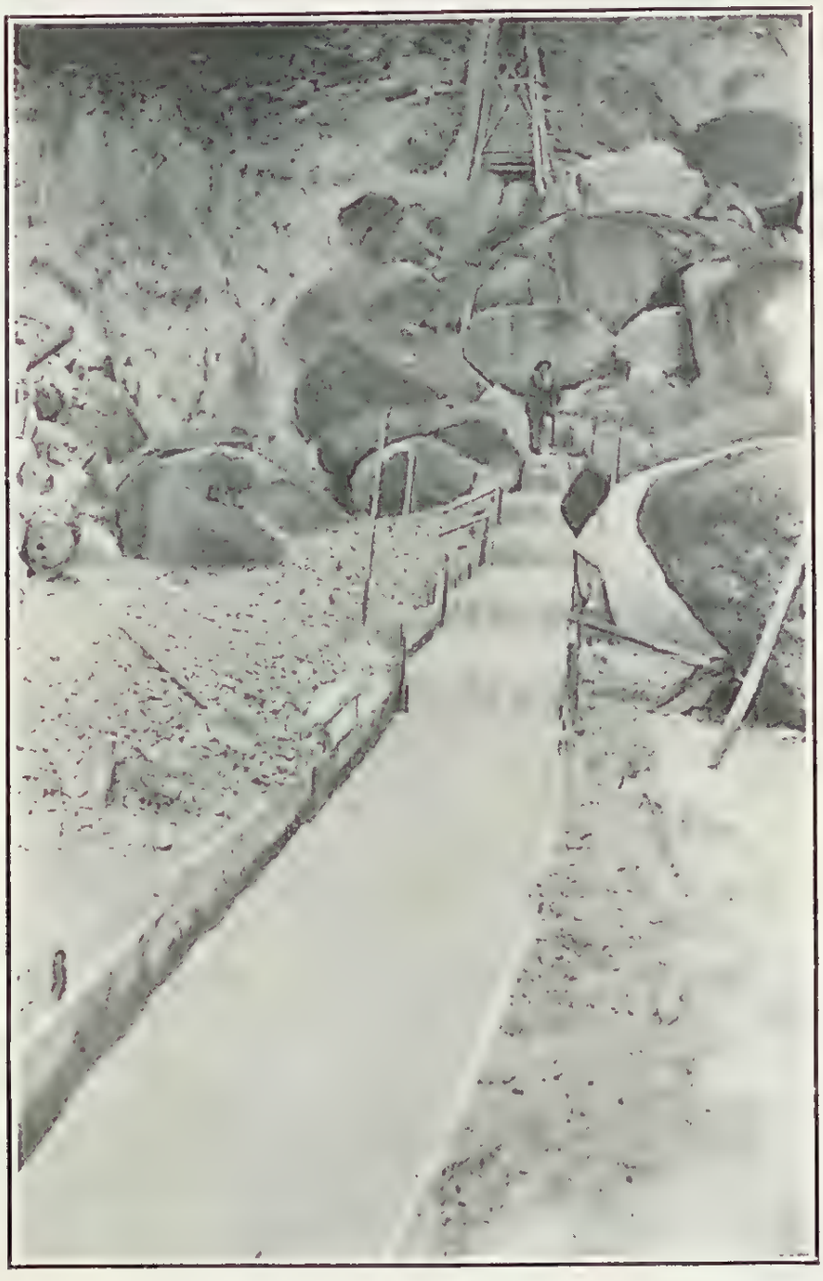
[*Photo., C. Francis.*

PLATE 46.—LODE HILL CLAIM, CHINA CAMP.
Showing nozzle at work.

At the head of this sluice-box a "grizzly" has been erected at a point 9 ft. 6 in. above the cement floor; the stone from the "grizzly" is trucked out along the right bank of Specimen Gully. The "grizzly" is 6 ft. wide and constructed of bars 6 ft. in length with an inch space between each; "fall," 2ft. 6 in. in the 6 ft. Through the centre of the open cut the sluice race is 6 ft. by 3 ft., and is boarded along the bottom and slabbed on the sides owing to the usually soft nature of the rock constituting the bottom of the cutting. It is found that the tinstone caught in the first three of the 22-ft. bays in the concrete sluice box represents about one-half of the total won.

A reference to the geological map (Map No. 3) accompanying these notes discloses the fact that the geological conditions obtaining on the area under review are comparatively simple, there being an area of slate formation—Gympie (?) in age—

intruded by a normal granite, the denudation of the stanniferous contact zone of the latter yielding recent alluvial deposits along the neighbouring waterways (Baird's Creek and its right (north) bank tributaries). Towards the margin of the intrusive rock the granite has been altered to some extent with the production of greisenised granite and occasionally true greisen. This



[*Photo., C. Francis.*

PLATE 47.—LODE HILL CLAIM, CHINA CAMP.
Sluice-boxes through the open cut.
Note the large boulders of hard granite.

greisenised portion of the rock mass was rendered stanniferous by the same agencies of hydrothermal activity as induced the greisenisation of the rock during the cooling process subsequent to its invasion of the previously existing slate formations.

The remarkable feature about this and other deposits—*e.g.*,

Annan River, etc., in the Cooktown region—is that not only are there the usual tin-bearing veins and leaders, etc., through the contact zone in the granite, but that the granite rock is itself notably stanniferous. Long centuries of heavy rainfall, and the presence of dense vine-scrubs and long grass, etc., have combined to make the granite sufficiently decomposed to allow of its being readily sluiced to a depth in the same way as an ordinary alluvial deposit would be treated.

As showing the comparatively recent geological age of the alluvial deposits at China Camp, it may be mentioned that stone tomahawks have in at least two authenticated instances been found embedded in the washdirt.

Some 13 acres of the greisenised granite formation on M.L. 207 has been bored by the present manager to a depth of 50 ft., and is stated by him to have yielded an average value of 1¼ lb. of tinstone per cubic yard. In addition to this area the formation can be traced still further eastward, as shown by several shallow prospecting shafts situated beyond the eastern boundary of this lease, particularly on M.L. 210.

Both coarse and fine-grained tinstone occurs, but the mineral maintains a definite character indicative of its lode origin. In colour it is largely brown, and much of it would be classed as resin tin. The tinstone is accompanied by a notable amount of black tourmaline, but very little black sand other than tourmaline has been met with hitherto. The coarser-grained particles of tin are frequently quite cellular in structure. Numerous pieces of specimen tin are found when sluicing, one piece discovered last year weighing about 63 lb. and estimated to yield 70 per cent. of tin ore when crushed. The majority of the specimens obtained up to the present show distinct evidences of having been derived from one or other of the numerous tourmaline-bearing quartzose leaders which traverse the contact zone. These leaders mostly strike in directions at right angles to the present points of contact of the granite and slate.

The depth of the working face at the time of my visit, in August, 1914, was from 70 to 100 ft. vertical. The maximum depth of material sufficiently decomposed to permit of sluicing is 210 ft., but the average thickness of treatable material would probably be not much in excess of 80 ft. In several places actual rock boulders are showing on the surface, but underneath these apparently solid rock formations the greisen is frequently decomposed.

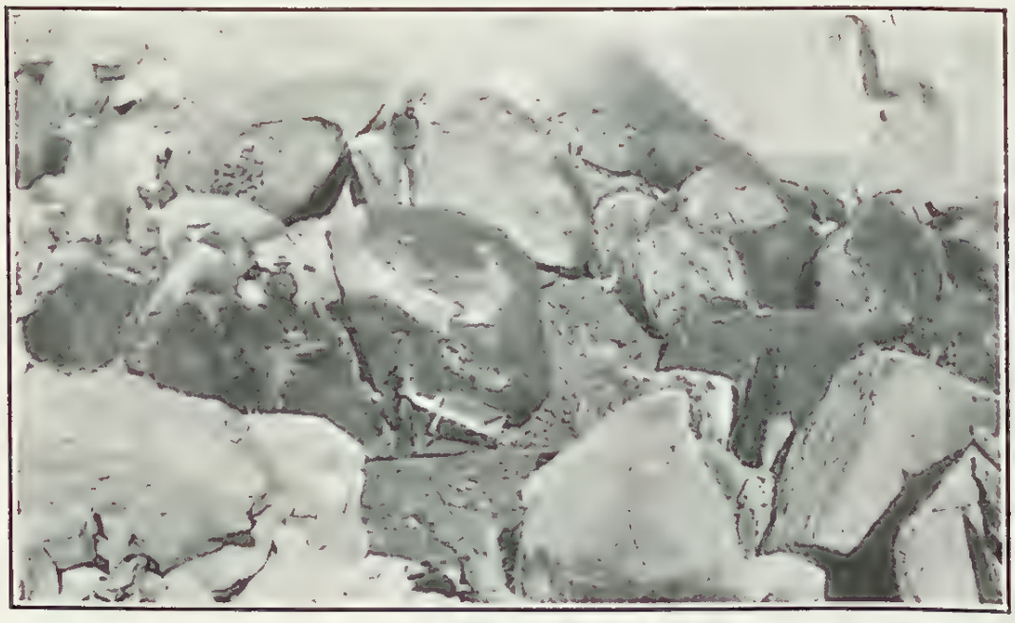
The whole of the mining operations conducted by the Lode

Hill Company have, so far, apart from the construction of the requisite head race and tail race, been limited to the large open cut extending from near the north-east corner of M.L. 214 across the northern half of M.L. 207 to near the eastern boundary of the latter lease. The position of this open cut has been fixed on the accompanying plan with fair accuracy, and a glance at the map will suffice to show that the cutting occupies the present exposed contact zone of the granite and slate rocks. At the lower (western) end of the open cut, close to the previously existing peg at the north-eastern corner of M.L. 214, the greisenised granite approaches very close to the ground surface, and is here characterised by numerous patches of tourmaline. The tinstone from this section of the workings exhibits the characteristic brown colour, and is stated to be in payable quantity. The stanniferous rock is here sufficiently decomposed to allow of being sluiced with nozzle pressure, but below that depth the greisen becomes gradually too hard to be broken down with water pressure. The rock has weathered to a creamy to yellow colour for the most part. Resting on the upper surface of the greisen at this point was some 5 ft. of surface red soil, which carried rich tin values, which undoubtedly have been derived from the denudation of the surface contact zone higher up the ridge.

The slate formation proper, into which the greisen has been intruded, makes its appearance along the northern side of the cutting, and on this face reaches a maximum thickness of about 40 ft. at a point some 4 chains along from the lower end of the workings. The greisen presents here a massive structure. The slate is of a deep reddish brown colour; it has a general southerly dip at an angle of 45 degrees, and has been completely decomposed to an average depth of 10 ft., but nowhere have explosives been necessary for the purpose of its removal. It is highly cleaved, the cleavages dipping north 10 degrees east at an angle of 50 degrees. No tinstone has been observed to pass upwards into this formation from the underlying intrusive stanniferous granite. The upper edge of the greisenised granite, as revealed in the open cut, shows it to here possess a south-westerly inclination at a rather low angle. No quartz leaders were exposed in this portion of the workings.

In the central portion of the open cut a pronounced ridge of relatively hard greisenised granite containing much tourmaline was exposed at a depth of 80 ft. from the then surface. This ridge of only slightly decomposed rock extends in an easterly direction through the cutting, and at the extreme eastern end of the workings it occupied a position about 117 ft. from the surface. On either side of this central ridge of harder

rock the decomposition zone coincides closely with the original surface contour of the ground, indicating that the hard ridge referred to constitutes the backbone of the spur down which the open cut has been made. The hard rock makes its appearance a short distance easterly of the former (Elliott and Skirving's) workings on the top of the surface ridge. The rock is here more truly a granite in type than that seen along the western end of the main open cut already described.



[*Photo., C. Francis.*

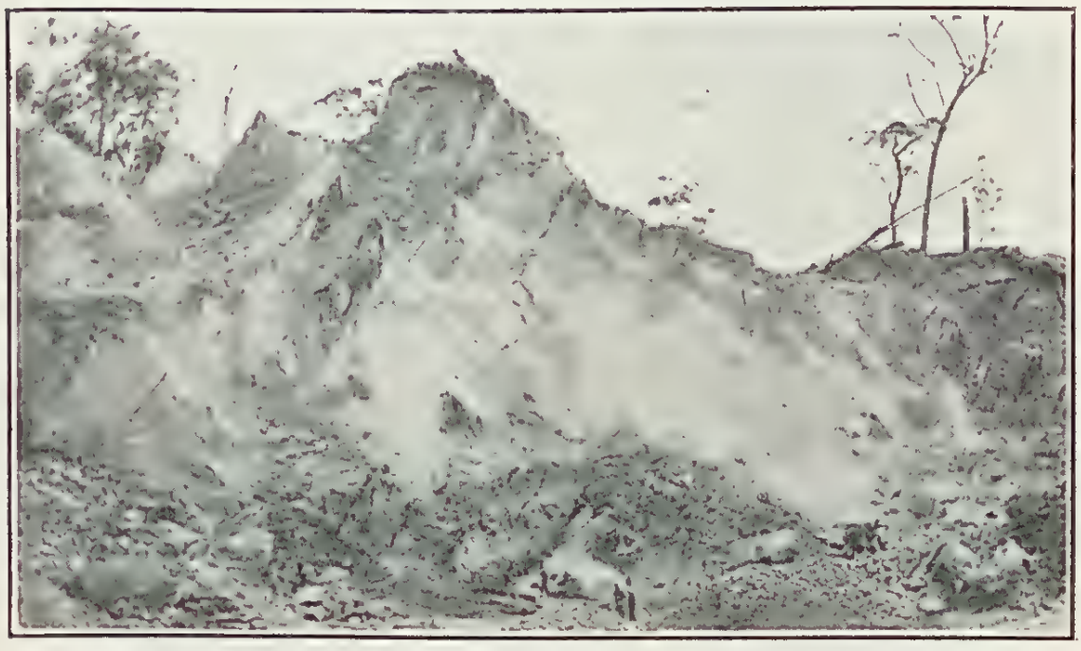
PLATE 48.—LODE HILL OPEN CUT.
Showing a nearer view of some of the granite boulders.

On the northern face of the cutting in this portion of the workings the intrusive nature of the granite is clearly shown by the presence of a well-marked dyke of greisenised granite radiating out from the main boss of that rock into the overlying slate formation. The thickness of this intrusive dyke is about 2 ft.; it dips south to its parent mass. This central portion of the workings has not proved so rich in tin values as the eastern and western ends of the open cut.

The accompanying sketch section, Section No. 1 (to scale) will serve to illustrate the mode of occurrence of the tinstone at Lode Hill; the section has been constructed along a north-south line across the open cut workings (*vide* also geological map No. 3, line A-B).

On the southern side of the working face exposed at the time of my examination, in August last, a hard band of grey quartzose tourmaline-bearing rock, containing occasional very rich tin specimens, formed the edge of the open cut. The average width of this formation has been 4 ft. The overlying slate having

been removed from off the eastern end by denudation, this rock was traced round and found to occur along the actual contact of the slate and greisenised granite. The dip of this band is south-westerly at an angle of 30 degrees. Tourmaline occurs here sometimes in segregations composed of radiating crystals aggregating many pounds in weight. The presence of these leaders has necessitated much handling of stone, as they have not become decomposed to anything approaching the extent seen in the granite host rock owing to the preponderance of quartz in their composition resisting the action of the decomposing agencies. A very rich patch of tinstone was found in the decomposed kaolinic material adjoining this leader.



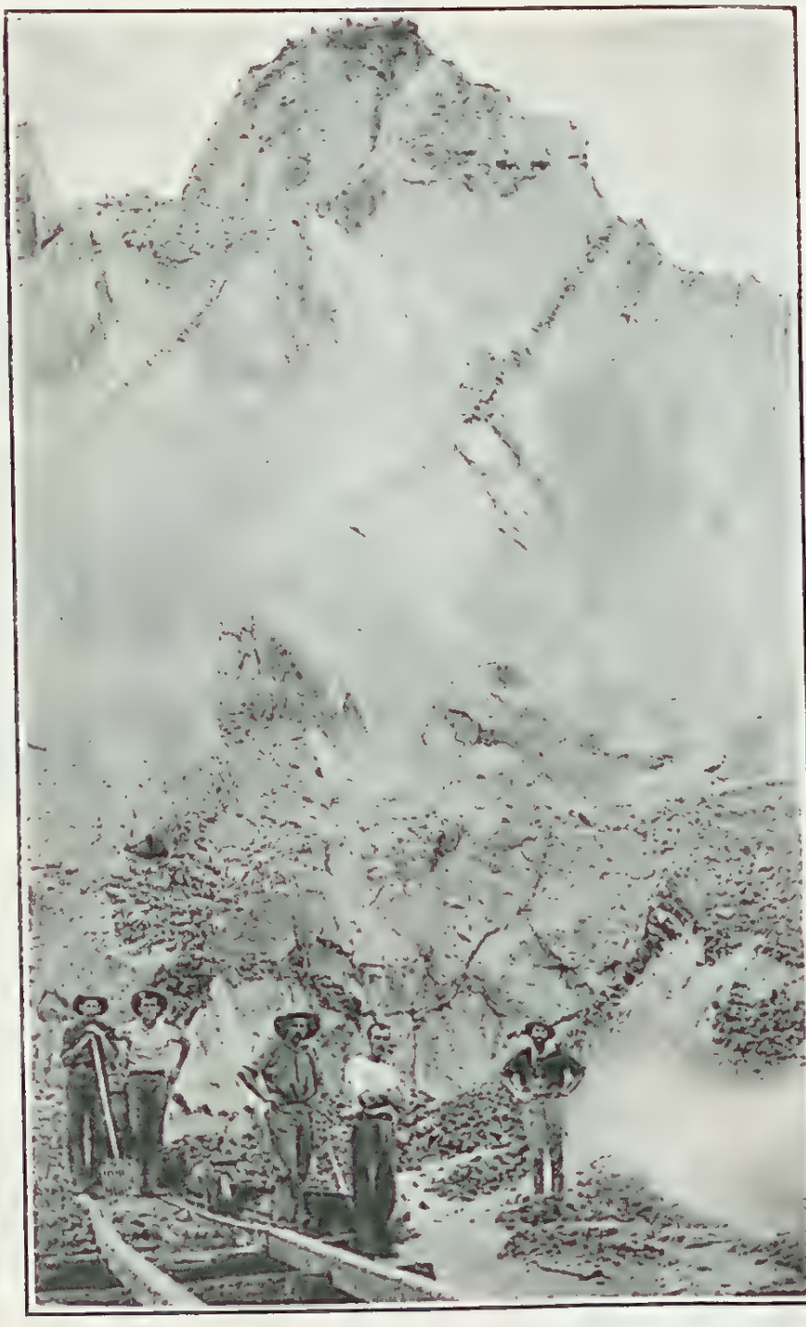
[*Photo., C. Francis.*

PLATE 49.—LODE HILL CLAIM, CHINA CAMP.
Showing portion of the face exposed by Messrs. Elliott and Skirving.

The working face at the eastern end of the cutting, when seen by me, consisted of over 100 ft. in thickness of stanniferous decomposed greisenised granite, and similar material could be seen to be extending underfoot. It is the intention of the owners to continue sluicing operations in a direction approximately south from the eastern end of the deeper workings to enable a tram line to be laid in order that the undecomposed granite boulders met with may be trucked out easily and dumped over the edge of the open cut into a depression near its southern side.

At the easternmost end of the workings carried out by the former owners, Messrs. Elliott and Skirving, the hard central ridge of granite above referred to comes to the surface. The tin values were particularly good in this section of the sluiced area. A well marked quartzose leader (*vide* map) runs through

the cutting hereabouts; dip east 30 degrees north. Good tin values were obtained alongside this formation. With the power at their command the greisenised granite could here be sluiced to an average depth of about 50 ft., but with the immensely greater pressure now available there should be no great difficulty experienced in breaking down the rock to a considerably greater depth if desired.



[*Photo., C. Francis.*

PLATE 50.—LODE HILL CLAIM, CHINA CAMP.
A nearer view of the face seen in Plate 49.
Showing tin-bearing leaders through the decomposed granite.

Mr. George Symons, foreman, informs me that a little wolfram has been recorded from the open cut workings, but that none has been noticed recently.

Timber is very costly owing to the scarcity of material suitable for the special requirements of the mining industry in this region. It is carried by aboriginals on their backs for at least three miles, the timber so transported usually being maple, silky oak, black oak, and red oak. I understand from the manager that the contract price for this timber delivered on the mine is £2 15s. per 100 superficial feet. From the experience gained up to the present it has been found that where concrete can be efficiently employed it is much cheaper to use than timber.

A new tin-cleaning and drying shed has lately been added to the equipment of this property. The heavy rainfall in this portion of the State renders it imperative to have such a convenience for the handling of the tin concentrates. The dimensions of this shed are 36 ft. by 18 ft. It is fitted with cemented floors, divided up into sections by concrete walls 3 ft. high. A tin dryer is also provided, the latter being set on concrete foundations, whilst the top work is made of bricks. The capacity of this dryer is about 1 ton at a time; its dimensions are 5 ft. high by 9 ft. long, with a grade of 2 ft. in 9 ft. It is estimated that this dryer will handle 12 tons of tinstone in the 24 hours. It is the intention of the owners to subsequently install a flying-fox from the sluice boxes to the tin shed, the motive power being furnished by a horse. The load expected to be delivered by this contrivance is from 7 to 9 cwt.

The total number of men employed in connection with this property is 27, working three shifts. At the time of my visit the wages being paid are stated to have been as follows:—Ordinary labourers, 11s. 8d.; tradesmen (carpenters, &c.), 13s. 4d.; nozzlemen, 13s. 4d.; box men, 12s.

The mine is lit up with one carbide lamp of 1,000 candle-power.

The year just passed has been by far the wettest experienced for a long time; in fact, I was informed locally that it has proved the wettest for the past 26 years. Mr. Northey has kindly supplied the accompanying figures, showing the registrations for the period December, 1913, to August, 1914:—Last week of December, 1913, 30 in.; January, 1914, 49 in.; February, no figures available, but wet month; March, 11½ in.; April, 8¾ in.; May, 6¼ in.; June, 5 in.; July, 4 in.; August, 9 in.

A movement has been set on foot in Cooktown to inaugurate a motor-boat service between that port and the Bloomfield River

landing place, and I am assured that the formation of a company with this object in view was well under way when the sudden outbreak of war caused matters to be allowed to stand in abeyance till the price of tin again reaches a satisfactory figure. The Lode Hill Company is taking a prominent part in the formation of the company for this motor-boat service, and I understand they offered to find one-third of the requisite capital. It is considered that a 15 h.p. boat will suffice for present requirements. The distance from Cooktown wharf to the entrance of the Bloomfield River is about 29 miles; a further 4 miles up stream brings one to the landing stage. The total cost of carting from Cooktown to the mine at present works out at slightly over £4 per ton, trips being made by a small sailing boat when cargo offers; the loading is then packed on horseback for 10 miles from the landing stage to the mine. There can be little doubt but that should a motor-boat service ultimately be put in operation a considerable trade could be worked up in the despatch to market of perishable produce (fruit, etc), for the growth of which the valley of the Bloomfield River is so admirably adapted. Should this motor-boat service be actually commenced it would prove of great benefit to the people of China Camp and the Bloomfield River if the mails could be carried on it instead of overland, as at present, seeing that the mail roads are practically impassable at times during the wet season.

The Roaring Meg crossing is a constant source of trouble during wet weather; conditions could be decidedly improved here by the erection of a wire across the river for the conveyance of mails and foodstuffs.

By the expenditure of a small sum a road could be made from China Camp to Ayton in such a way that neither the Bloomfield River nor Roaring Meg would need to be crossed: the distance would be about 22 miles, as compared with 14 miles, as at present, but the benefits derivable appear to warrant some attention being given to this question.

THE ROARING MEG HYDRAULIC SLUICING COMPANY, NO LIABILITY.*

Office, 18 Bridge street, Sydney; John Gainford, secretary; local manager, Ivar Olsen; Cooktown agent, W. R. Humphrey. This company's property is also situated at China Camp, adjoining the Lode Hill leases along the western boundary of the latter.

* Since my return to Brisbane I have been informed that this claim has now passed into the hands of the Lode Hill Company, who intend working it in conjunction with their own leases.

Operations were first commenced here by this company in November, 1908, and work was carried on fairly continuously up to the time of my visit, in August, 1914, the principal sites lately worked being along Specimen and Tunnel Creeks. Unlike the occurrence of the tinstone at Lode Hill, described in the foregoing, the mineral is here found under the usual conditions of a true alluvial deposit—viz., in ordinary stream-borne alluvial along and adjacent to waterways draining stanniferous formations.

Plate 51.—Shallow Alluvial Deposits, Roaring Meg Claim, China Camp.

As in the case of the Annan River tinfield, a little alluvial tin is scattered over the whole ground surface of the leases comprising this property, and the geological map accompanying this

report attempts to give, as accurately as the circumstances permit, an idea of the area of alluvial deposits along the stream channels which may be rightly set down as stanniferous alluvial material.

Along *Specimen Creek*, which takes its rise near to the Lode Hill Company's sluice box and joins Tunnel Creek towards the centre of M.L. 211, tin has been worked at various times from mere "surfacing" to depths of as much as 20 ft. The whole course of this gully is over slate country. The washdirt averages about 3 ft. in thickness, and is composed largely of waterworn slate and granite with numerous specimens, hence the name. These specimens undoubtedly owe their origin to one or other of the numerous tin-bearing leaders traversing the granite of Lode Hill up stream.

Tunnel Creek constitutes the main right bank tributary of Baird's Creek at China Camp; it heads in a small gully on M.L. 207 below the main Lode Hill workings, and follows a general westerly course through M.L.'s 216, 203, and 211,

[*Photo., C. Francis.*

PLATE 52.—A RICH ALLUVIAL CLAIM (CHRISTY SORENSEN'S) IN TUNNEL CREEK, LODE HILL COMPANY'S PROPERTY, CHINA CAMP.

uniting with the main creek a short distance south of M.L. 205. As in the case of its right bank tributary, Specimen Creek, just mentioned, its course is from the slate-granite contact over slate country for its entire length. The tin occurs in much the same manner as in the case of Tunnel Creek, except that depths of 30 ft. have been obtained in the alluvials.

Near the north-eastern corner of M.L. 216 there is a rich deposit of tin still available for sluicing. A view of this area—

previously owned by Christy Sorensen, and since purchased by the Lode Hill Company, is given in the accompanying photograph (Plate 52).

PLATE 53.—STRIPPING OVERBURDEN WITH A NOZZLE, ROARING MEG CLAIM.

Dishes of dirt seen by me washed from this area gave remarkable yields. In the case of the majority of the sites worked along this gully, it has been found that the tinstone occurs through the overburden as well as in the 4 to 5 ft. of bottom wash-dirt.

Along the southern portion of M.L. 203 a considerable amount of sluicing has been done on the areas known as Midas Flat, McGuie's, Coleman's, etc. (*vide* Map No. 3).

Towards the south-western corner of M.L. 205 Baird's Creek

is joined on the western boundary of that lease by a small creek, the left branch of which is called *Wilson's Creek,* whilst the right-hand branch goes under the local name of *Waugh's Creek.* Wilson's Creek is a small gully heading in the northern portion of M.L. 203, and from its source downwards it has been worked at various times, as also have the adjoining shallow surface deposits. Skogstrom's and Varley's claims were situated on this creek and a small right-bank tributary. Waugh's Creek is a much longer creek and heads in the granite ridge on M.L. 207, the claims on the upper portion of the creek being known as Bolte's and Bolte's West. Lower downstream (close to the Lode Hill Company's office) a small left-bank gully was worked for a time by Murray.

A considerable area has been sluiced near the boundary of M.L. 205, at what is known as the Garden Face, by reason of its nearness to an old fruit garden.

Stockyard Gully takes its rise close to the south-eastern corner of M.L. 206, and after maintaining a north-westerly trend to as far as the western boundary of that lease, it turns southwards into Baird's Creek, which latter it enters on portion 281. By far the greater amount of work carried out along this depression has been shallow surfacing in the neighbourhood of the south-eastern corner of M.L. 206, and a lesser amount on a small right-bank tributary gully along the western boundary of the lease. The tin was in payable quantity and rather more waterworn than that seen elsewhere at China Camp. A little very fine waterworn gold and an occasional blue sapphire were obtained during sluicing operations along this gully.

Knox's Creek heads in granite country close to the north boundary of M.L. 208, and flows through that lease and the westerly adjoining one—M.L. 206. The alluvial worked on M.L. 208 averaged 15 ft. in depth and rested on both granite and slate bottoms; the easternmost workings were known as Knox's No. 1, whilst those on M.L. 206 were called Knox's West.

Water for sluicing purposes is obtained by this company from the Roaring Meg River, and conveyed to the present working face by siphons, pipes, and a race. Some 150 ft. of pressure is available, but at the time of my visit the siphons and pipes were in bad repair. The water is conveyed to the face by means of a 7-in. pipe column, with 1¾-in. jets in both nozzle and elevator. The capacity of the plant is given as 300 cubic yards per shift. Three shifts have been worked at times, but on the occasion of my examination no work was in progress. When

in full swing a total of 15 men were employed on this property. According to the manager's statement to me, the material treated has averaged from 1½ to 2 lb. of tinstone per cubic yard at recent wash-ups.

For valuable assistance in locating the position of the different working places on these leases, I am indebted to Mr. J. R. Raleigh, formerly manager of the Roaring Meg Company.

Plate 54.—Sluicing Alluvial Deposits Along a Gully, Roaring Meg Claim.

The Pocket.

That portion of the China Camp field situated on Boulder and Granite Creeks to the south of M.L.'s 207 and 210 is locally known as The Pocket. Most of the work carried out in recent

years has been along the right bank of Boulder Creek, which creek constitutes a right-bank tributary of Granite Creek (*vide* plan). Boulder Creek heads near the north boundary of M.L. 213, and maintains a general south-south-westerly trend through that block and the adjoining M.L. 210. The only claims being worked on the occasion of my visit were Knowlton's and Skogstrom's.

Knowlton's Claim is located along the right bank of Boulder Creek, close to the junction of the latter with Granite Creek. Several chains in length have here been recently sluiced by the owner. A nozzle is used, water being obtained from a race some three miles in length from Horse Creek. Numerous large boulders of blue quartzite (frequently mistaken here for diorite) are met with in the overburden and also through the washdirt. The tinstone is waterworn and brown in colour for the most part. No gem stones have been recorded from this area. The owner informs me that up to the present he has won some 12 tons of tinstone, assaying up to 73·8 per cent. in bulk.

Skogstrom's Claim, owned and worked by Johan Skogstrom.—This claim is situated near the right bank of Boulder Creek, a short distance upstream from Knowlton's claim. At the time of my examination, in August last year, the owner was sluicing the surface portion of the alluvium. The lower end of the claim shows large granite boulders through the overburden and washdirt. The bottom rock is here slate, as indeed is the case of Knowlton's claim. The gravel occurs in bands all through the overburden. The ground shows every appearance of deepening on the western side of the claim. No very extensive work has been carried out here, as sluicing is only possible during the rainy season, owing to the smallness of the water supply.

Returns for Five Years.

The appended returns of the quantity and value of tinstone won from the Bloomfield River region now under review for the five-year period ending 31st December, 1914, as lately furnished to the Mines Department by Mr. Warden Power, of Cooktown, should prove of interest:—

Locality.	1910.		1911.	
	T. C. Q. L.	£ s. d.	T. C. Q. L.	£ s. d.
Roaring Meg	23 12 0 13	2,227 0 0	23 13 0 2	2,795 4 5
Bloomfield...	5 5 2 27	509 3 8	10 2 3 8	1,150 15 9
Lode Hill	54 11 2 7	5,307 10 0	34 1 1 0	3,985 10 0
China Camp	...	...	...	...

Locality.	1912.							1913.							1914.						
	T.	C.	Q.	L.	£	s.	d.	T.	C.	Q.	L.	£	s.	d.	T.	C.	Q.	L.	£	s.	d.
Roaring Meg ...	20	15	0	5	2,784	8	4	12	4	2	25	1,625	6	0	6	1	1	14	640	15	0
Bloomfield ...	13	11	1	19	1,879	18	4	14	7	3	11	1,859	1	4	11	12	1	4	1,258	10	0
Lode Hill ...	39	15	0	20	5,319	17	9	19	4	1	27	2,607	11	0	48	5	0	25	4,850	10	0
China Camp ...	0	6	0	0	38	0	0	...				...			0	6	0	0	28	0	0

From the above figures it will be seen that the Lode Hill claim has during the past five years produced a total of approximately 196 tons of tinstone, valued at slightly over £22,000, whilst the adjoining Roaring Meg property, which has been recently reported as having been acquired by the Lode Hill Company, has, in the same period, been responsible for an additional 86 tons, valued at £10,000, or a total production for the two claims of about 282 tons, valued at approximately £32,000.

Future Prospects of the Field.

Taking into consideration the extensive area of payably stanniferous greisenised granite country, the depth and extent to which decomposition of that rock has been there carried, the magnificent water supply available from the Bloomfield River, the excellent "fall" obtainable for the nozzle supply, etc., I am of opinion that the Lode Hill property will prove a fairly remunerative venture, seeing that the working costs can be reduced to a figure much lower than that usually obtaining for sluicing propositions. The water obtained from their head race is in a particularly favourable position, commanding as it does the whole of the China Camp tinfield, including the Roaring Meg leases, the Pocket, etc.

Brisbane, 9th March, 1915.

Appendices.

A.—Mineral Leases, Etc., in force as on 31st January, 1915.*

Mineral Leases.

No.	Holder and Locality.	Area. A.	R.	P.
176	Annan River Co., N.L., Collingwood	62	0	18
177	Annan River Co., N.L., Collingwood	35	0	0
197	David Lindsay, Home Rule	18	0	15
203	Roaring Meg Hyd., N.L., China Camp	36	3	10
207	Lode Hill Tin Mines, N.L., China Camp	40	0	0
208	Roaring Meg Hyd., N.L., China Camp	10	0	0
210	Lode Hill Tin Mines, N.L., China Camp	20	0	0
211	Roaring Meg Hyd., N.L. China Camp	10	0	0
213	Lode Hill Tin Mines, N.L., China Camp	20	0	0
216	Lode Hill Tin Mines, N.L., China Camp	6	0	27
217	Gustave Antoine Collin, Mount Amos	30	0	0
218	Annan River Co., N.L., Rossville	80	0	0
220	John Skirving, Mount Romeo	20	0	0
221	Leslie Arthur Davies-Griffith, Mount Hartley ..	20	0	0
223	John Skirving, Mount Romeo	6	0	0
224	Horan and party, Old Bloomfield Scrub	10	0	0
225	Gustave Antoine Collin, Mount Amos	10	0	0
227	Annan River Co., N.L., Collingwood	50	0	0
228	Annan River Co., N.L., Collingwood	9	1	18
229	Will Norris, Mount Amos	10	0	0
230	Will Norris, Mount Amos	10	0	0
231	John Thomas Elliott, Mount Amos	10	0	0
232	Ambrose John Madden, Slatey Creek..	20	0	0
233	A. H. and F. J. Francis, Rossville	30	0	0
234	Simon Spargo, Shipton's Flat	10	0	0
235	John Horan, Old Bloomfield Scrub	10	0	0
236	Ambrose John Madden, Mount Finlayson	160	0	0
237	Ambrose John Madden, Mount Finlayson	40	0	0
239	Lode Hill Tin Mines, N.L., China Camp	12	0	0
240	Arthur C. and H. Percy Shipton, Shipton's Flat ..	20	0	0
241	Joseph Thomas Bell and Walter James Colley, Mount Leswell	10	0	0

Gold Mining Leases.

17	Starcke United Gold Mines, Ltd., Munburra.. ..	5	0	0
21		22	0	0
24		3	2	27·5
30	Karl A. Muller, Alice River	5	0	0

* Information kindly supplied by Mr. Warden Power, Cooktown.

Miners' Homestead Leases.

7	Frederick Corbett, Mount Leswell	5	0	0
8	George Butcher, Starcke	1	0	0
9	Lode Hill Tin Mines, N.L., China Camp	3	1	30
10	Johan Skogstrom, China Camp	3	1	30
11	Robert John Sikkema, Shipton's Flat	5	0	0
14	Wm. Collins, Bloomfield	41	3	30
15	Wm. G. Cleary, Rossville	1	0	0
16	Walter J. Davies, Rossville	0	3	8
17	Nemo. Bathe, Grasstree	1	0	0
19	Wm. E. Watkin, Rossville	0	2	0
20	Thomas J. Dowling, Rossville	0	2	0
21	Wm. F. Trevorrow, Rossville	0	1	32
22	Johan Johanson, Rossville	0	0	35·2
23	Henry von Bremen, Rossville	0	1	12·3
24	Robert Gordon, Starcke	5	0	0
26	Harriet Ann Davies, Rossville	0	1	30
27	Joseph Kelly Davies, Rossville	0	1	30

Dredging Claims (Tin).

1020	Charles Patching, Mount Romeo	71	0	0
1023	Wm. Pocock, Annan River	300	0	0
1024	Wm. Pocock, Annan River	300	0	0
1114	Annan River Co., N.L., Rossville	96	2	14
1142	Miller, Parkes, and Cummins, Mount Windsor ..	100	0	0
1151	Bathe, Doolan, Bolen, and Bathe, Mount Romeo ..	90	0	0
1171	Morison, Connelly, and Parkes, Mount Windsor ..	24	0	0
1180	George Goodman, Helenvale	235	0	0
1181	Wales and Party, Mount Poverty	127	1	17
1182	Lode Hill Tin Mines, N.L., Mount Romeo	100	0	0
1183	Annan River Co., N.L., Rossville	100	0	0
1184	Thos. F. Ross, Tableland	63	2	30

Machine Areas.

15	James B. Stewart and Robert Gordon, Munburra ..	2	0	0
20	John Thomas Elliott, Mount Amos	5	0	0
21	Annan River Co., N.L., Rossville	5	0	0

B.—Cape York Peninsula Gold and Mineral Fields: Comparative Statement of Tin Production for the Years 1910 to 1914 inclusive.*

Locality.	1910.				1911.				1912.				1913.				1914.			
	T.	C.	Q.	L.	£	s.	d.	T. C. Q. L.	£	s.	d.	T. C. Q. L.	£	s.	d.	T. C. Q. L.	£	s.	d.	T. C. Q. L.	£	s.	d.
Cooktown Field.																							
Rossville ..	96	18	3	11	9,269	19	8	29 8 3 20	3,357	15	6	34 14 3 0	4,630	11	0	39 17 1 1	5,155	11	9	32 1 3 10	3,250	17	6
Shipton's ..	13	2	3	21	1,279	6	5	10 13 0 3	1,244	11	0	15 16 3 7	2,168	8	0	17 16 3 7	2,393	11	10	11 18 2 17	1,167	2	0
Mount Hartley ..	15	1	0	8	1,437	5	0	8 19 2 9	998	10	0	2 14 3 0	336	15	0	1 2 0 6	127	0	0	6 11 3 8	676	0	0
Mount Poverty ..	3	8	1	15	325	12	5	2 10 3 2	302	5	1	1 1 2 26	143	0	0	2 1 1 22	259	17	2	0 14 1 0	84	15	0
Mount Leswell ..	0	16	0	0	77	0	0	0 11 0 0	124	0	0	..	..			0 18 3 0	114	12	0	0 9 0 6	46	12	6
Tableland ..	10	16	1	8	1,030	0	0	3 6 4 0	372	8	0	10 10 1 21	1,294	0	0	10 6 0 25	1,203	10	0	6 10 2 23	623	12	0
Finlayson ..	8	3	1	9	786	11	6	3 13 3 7	428	13	6	3 3 3 2	420	3	8	1 1 0 0	134	0	0	1 7 0 6	145	0	0
Helenvale ..	0	5	0	6	24	15	0	0 15 1 9	83	0	0	0 1 3 14	10	18	0	..	..			0 13 0 0	72	0	0
Mount Amos ..	22	10	0	25	2,173	0	0	11 1 0 10	1,209	3	0	18 8 0 4	2,374	5	10	20 18 3 16	2,670	2	9	9 0 2 11	943	6	6
Mount Romeo ..	18	12	1	1	1,830	13	3	18 12 2 13	2,135	8	0	38 5 2 22	5,332	18	7	37 8 2 16	4,878	4	1	25 3 0 7	2,680	9	0
Grasstree ..	13	12	2	12	1,337	11	6	12 15 0 27	1,485	19	0	3 0 1 3	397	11	0	12 2 1 26	1,718	10	0	0 8 0 0	40	0	0
Lode Hill ..	54	11	2	7	5,307	10	0	34 1 1 0	3,985	10	0	39 15 0 20	5,249	17	9	19 4 1 27	2,607	11	0	48 5 0 25	4,850	10	0
Roaring Meg ..	23	12	0	13	2,227	0	0	23 13 0 2	2,795	4	5	20 15 0 5	2,784	8	4	12 4 2 25	1,625	6	0	6 1 1 14	640	15	0
Bloomfield ..	5	5	2	27	509	3	8	10 2 3 8	1,150	15	9	13 11 1 19	1,879	18	4	14 7 3 11	1,859	1	4	11 12 1 4	1,258	10	0
Home Rule ..	..				..			9 6 0 0	1,138	0	0	9 2 0 0	1,241	10	0	27 1 2 10	3,427	0	0	7 10 0 20	717	10	6
Slatey Creek ..	..				..			0 4 0 0	24	0	0	..	..			0 5 2 20	29	10	0	1 16 2 21	202	2	0
Annan River Coy. No Liability	..				..			5 14 2 0	595	0	0	33 12 0 8	4,389	19	0	62 18 2 22	8,265	10	0	43 19 2 25	4,148	8	8
China Camp ..	..				..			..	..			0 6 0 0	38	0	0	..	..			0 6 0 0	28	0	0
Mount Misery ..	..				..			..	..			0 3 2 0	21	9	0	..	..			..	..		
Total ..	286	16	2	5	27,615	8	5	185 9 3 26	21,430	3	3	250 0 22 3	33,419	0	10	279 16 2 4	36,468	17	11	214 9 1 23	21,575	10	8
Mount Amos (lode)	..				..			..	..			..	..			..	..			7 0 3 9	592	19	0
Phœnician (lode)	4	3	2	16	322	17	9	6 8 0 0	691	0	0	16 14 0 21	2,117	13	0	1 10 1 17	176	3	0	1 14 0 0	166	0	0
Total ..	291	0	0	21	27,938	6	2	191 17 3 26	22,121	3	3	266 14 2 24	35,536	13	10	281 6 3 21	36,645	0	11	223 4 1 4	22,334	9	8
Palmer Field.																							
Granite Creek ..	38	2	0	13	3,460	10	7	8 17 0 22	1,025	10	0	0 4 1 25	27	11	9	0 2 0 10	13	10	2	..	..		
Mount Windsor	12	4	2	24	1,185	0	8	12 2 0 4	1,428	11	7	8 9 3 26	1,231	7	5	7 5 2 8	965	10	5	2 7 1 12	256	11	0
Cannibal Creek ..	..				..			20 3 3 18	2,412	18	10	23 16 2 10	3,139	16	11	20 19 3 11	2,634	11	0	14 16 1 5	1,569	15	0
Campbell's Creek	..				..			6 10 2 3	731	19	3	4 14 3 16	606	17	7	3 7 0 6	422	10	3	0 11 2 14	60	18	0
Total ..	50	6	3	9	4,645	11	3	47 13 2 19	5,601	19	8	37 5 3 21	5,005	13	8	31 14 2 7	4,036	1	10	17 15 1 3	1,887	4	9
Bowden Field.																							
Pascoe River ..	..				..			..	..			..	..			0 5 3 17	30	0	0	0 9 3 13	51	7	0
Archer	4	12	2	8	439	19	2	3 19 3 22	437	18	0	5 10 2 14	696	0	3	11 11 2 15	1,390	8	4	..	..		
Total ..	4	12	2	8	439	19	2	3 19 3 23	437	18	0	5 10 2 14	696	0	3	11 17 2 4	1,420	8	4	0 9 3 13	51	7	0
Grand Total	345	19	2	10	33,023	16	7	243 11 2 12	28,161	0	11	309 11 1 3	41,238	7	9	324 19 0 4	42,101	11	1	241 9 1 20	24,273	0	8
	= £95 9s. 9·41d. per ton.				= £115 1s. 2·7d. per ton.				= £133 4s. 3d. per ton.				= £129 11s. 3d. per ton.				= £100 11s. 2·58d. per ton						

* Information taken from the Annual Report of the Warden, Cooktown, for the year 1914.

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Map No. 3.—Geological Map of Lode Hill, Roaring Meg, Etc., Tin Mines, China Camp, Bloomfield River, Cooktown District.

Section No. 1.—Section Across the Lode Hill Workings, China Camp.

MAP Nº2.

Geological Map of the ANNAN RIVER TINFIELD

COOKTOWN MINING DISTRICT

TO ACCOMPANY REPORT BY

E.C.Saint-Smith, A.S.T.C., Assistant Govt Geologist.
Assisted by R.Graff.

1915

Scale of Chains
20 0 20 40 60 80 100 120
F.B Del.

Prepared at the Department of Mines Brisbane, Q. 1916.
Nº 250 Geological Survey Publication

Reference.

- Recent and Post-Tertiary (Stanniferous Alluvials)
- Basalt (Post-Tertiary)
- Granite (Intrusive) and Associated Porphyry Dykes
- Slates, Quartzites, Schists etc (Gympie?)

PARISH OF MONKHOUSE
COUNTY OF BANKS
PARISH OF PHIPPS
COUNTY OF SOLANDER
PARISH OF CLERK

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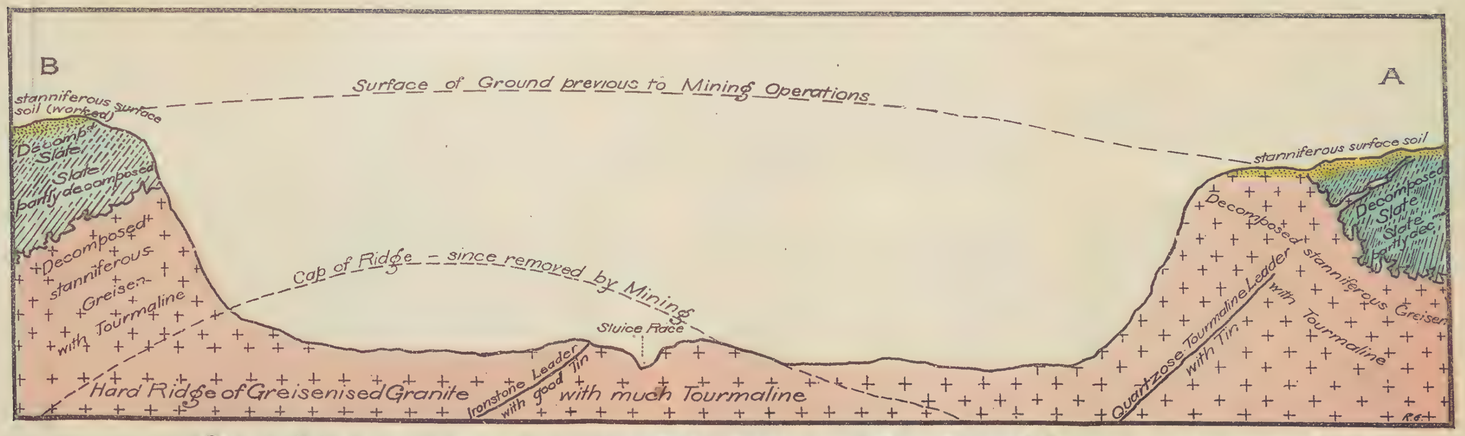
VICT

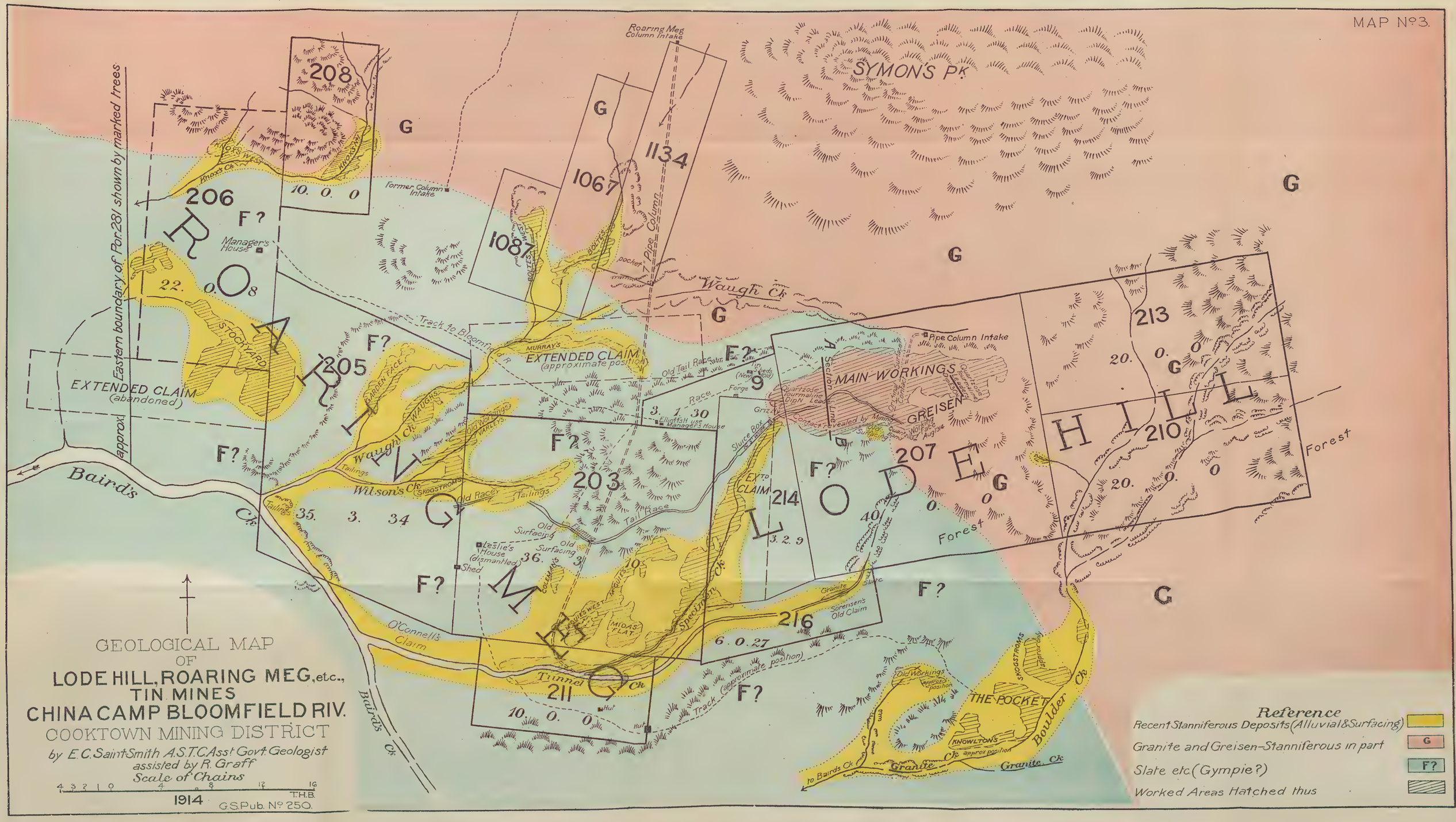


Section across LODE HILL WORKINGS on Line A-B.

Scale

0 10 20 30 40 50 100 feet

MAP No 3.



GEOLOGICAL MAP OF LODE HILL, ROARING MEG, etc., TIN MINES CHINA CAMP BLOOMFIELD RIV. COOKTOWN MINING DISTRICT

by E.C. Saint-Smith A.S.T.C Asst Govt. Geologist assisted by R. Graff

Scale of Chains

4 3 2 1 0 4 8 12 16

T.H.B.

1914 G.S.Pub. No 250.

Reference

- Recent Stanniferous Deposits (Alluvial & Surfacing)
- Granite and Greisen-Stanniferous in part — G
- Slate etc (Gympie?) — F?
- Worked Areas Hatched thus

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Queensland.

DEPARTMENT OF MINES.

Geological Survey of Queensland.

(B. DUNSTAN, GOVERNMENT GEOLOGIST.)

PUBLICATION No. 251.

The Wolfram Mines

OF

MOUNT CARBINE,

North Queensland,

With 1 Map, 24 Figures, and 21 Photographs.

BY

LIONEL C. BALL, B.E. (Syd.),

ASSISTANT GOVERNMENT GEOLOGIST.

BRISBANE

BY AUTHORITY: ANTHONY JAMES CUMMING, GOVERNMENT PRINTER.

1915.

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SURFACE PLAN
OF
MOUNT CARBINE

BY

LIONEL C. BALL, B.E.,
Assistant Govt. Geologist.

Based on surveys by Surveyors
Cobon, Rankin, and Woodward.

0 8 16 24
Scale of chains

E.F.E.

Pew-Paw Gully
True Blue zone
Daisy Gully
Daisy zone
Watsons Gully
Beadles Gully
Owens Gully
Ruby Gully
Iron Duke zone
Bonser zone
Scheelite Gully
Dazzler zone
Johnson zone
Mt Manis Gully
Ruby Gully
Prices Creek
Mill Gully
Borden Creek
Ana Branch
Manganese Creek
FELSITE DYKE
GRANITE
M.L. 3174 TUNGSTEN
M.L. 3283 D.C.L. POLYGONIC
R.S.B.
Eye Opener
Ruby United
Little Nell
Edith
Triangle
Harp
Lone Hand
Lucky Hit
X-Rays
Iolanthe
Natives
Johnson
M.L. 3273
M.L. 2878 Rolfe
Rolfe Adit
M.L. 2225 Mt Carbine No 1
Mt Carbine Adit
No 1
No 2 Adit
No 3 Adit
Cassel's Adit
Hartley's Adit
Mill Adit
M.H.L. 2123 G.C. Young
M.H.L. 2122 F.C. West
M.H.L. 1472
Magazine
Residence
Office
Mill
M.L. 3149 COMBINATION
Tail Dams
M.L. 3150 DAM SITE
M.L. Pumping 3156 Site PUMP SITE
Company's well
Hospital Res
M.L. 3073 WELLBECK ABBEY
M.L. 3074 Tramway
M.L. 3075 Race
M.L. 3076 Tailings
M.H.L. 1831 Town well
Township of Mount carbine
BAIRD STREET
Court House
I School Res.
2 Recreation Res
I II III IV V VI

LEGEND

Pads shown thus
Roads shown thus
Surface (vein) workings
Floater (alluvial) workings
Mullock dumps
Claims and leases shown
Creeks shown
Contours shown

LEASES.

M.H.L. 2122 F.C. West
" 2123 G.C. Young
M.L. 2225 Mt. Carbine No 1
" 2878 Rolfe
" 3073 Welbeck Abbey
" 3074 Tramway
" 3075 Race
" 3076 Tailings
" 3149 Combination
" 3150 Dam Site
" 3156 Pump Site
" 3174 Tungsten
" 3273 Johnson

CLAIMS.

M.C. 9587 Ruby United
" 8296 D.C.L.
" 9426 R.S.B.
" 9730 Eye Opener
" 7242 Little Nell
" 7237 Edith
" 7238 Triangle
" 8068 Harp
" 7270 Lone Hand
" 7442 Lucky Hit
" 7709 X-Rays
" 9485 Iolanthe

The Wolfram Mines of Mount Carbine, North Queensland.

By Lionel C. Ball, B.E., Assistant Government Geologist.

INTRODUCTION.

Mount Carbine was visited by the writer in connection with the preparation of a monograph on the occurrence and mining of rare metals in Queensland. The whole of October and the first half of November, 1912, was spent in the locality, much of the time being devoted to cartography. No laboratory work has yet been attempted, but that the statistical matter might not fall hopelessly out of date, it was thought advisable to publish these field notes in advance of the complete report, first of all in the "Queensland Government Mining Journal" (see issues of February, March, and April, 1912), and now in handier bulletin form.

History.

That the abundant black shoads on Carbine Hill attracted the attention of the early settlers of the district is attested by the appellation of the adjacent watercourse, Manganese Creek, other manganese ore of any variety than the wolfram being conspicuously absent. It cannot have been many years before the true nature of the substance became known, but the want of transport facilities precluded its exploitation until recently and after the more favourably situated deposits at Bamford and Wolfram Camp had received attention. Healy and Althous in 1895 or 1896 sent 28 cwt. of wolfram to Sydney; but, as this was paid for at the rate of only £8 per ton, which just about cleared expenses, nothing much was done till 1897, when a parcel (for which a Wolfram Camp buyer offered £8 per ton) was sent to Sydney for shipment to London in 1898. The returns came back the following year: £90 per ton clear of expenses after leaving Port Douglas; and the price of wolfram in Mount Carbine when the return was received was but £40 per ton!

The subsequent history of the field is something of a blank, the operations having been on too small a scale to be

deemed worthy of record. This may have been true as far as any individual prospector's results were concerned, for very few made more than good wages and few stayed long on any one piece of ground, but in the aggregate the amount of work done was certainly considerable.

The first claim registered at Herberton was the Nil Desperandum (M.C. 7207). This was in 1904; but it would seem that Baird's Bluff, which it adjoined, had been some time previously pegged out.

With the initiation of the Mount Molloy Company's project to connect their copper mines with Biboohra by rail (ultimately consummated in 1908), there was opened a prospect of greatly

PHOTO. 1.—CARBINE HILL, FROM HOSPITAL, SHOWING WORKINGS AND MILL.

reducing the cost of transport to and from Mount Carbine, and as early as 1906 the Irvinebank Company began to acquire control over all the principal holdings, the prospectors being at the end of their resources, as most of the rich surface ore had been rooted out and naturally no reserves of capital had been laid by for sinking and developing the claims. The company has directed most of its attention to the Johnson and Mount Carbine No. 1 leases. Several adits have been driven into the hill, and the backs are now being systematically worked out by overhand stoping, the ore being passed and trucked to an adit which opens directly above the supply bins at the mill. The battery, completed in July, commenced running in August, 1911, after exhaustive test had been made by Mr. F. C. West, the present manager, to determine the average metallic content

of the ore-bodies. The success of the enterprise has been gratifying, and a weekly production of 5 tons wolfram concentrate is being closely adhered to. Just now the company is not working

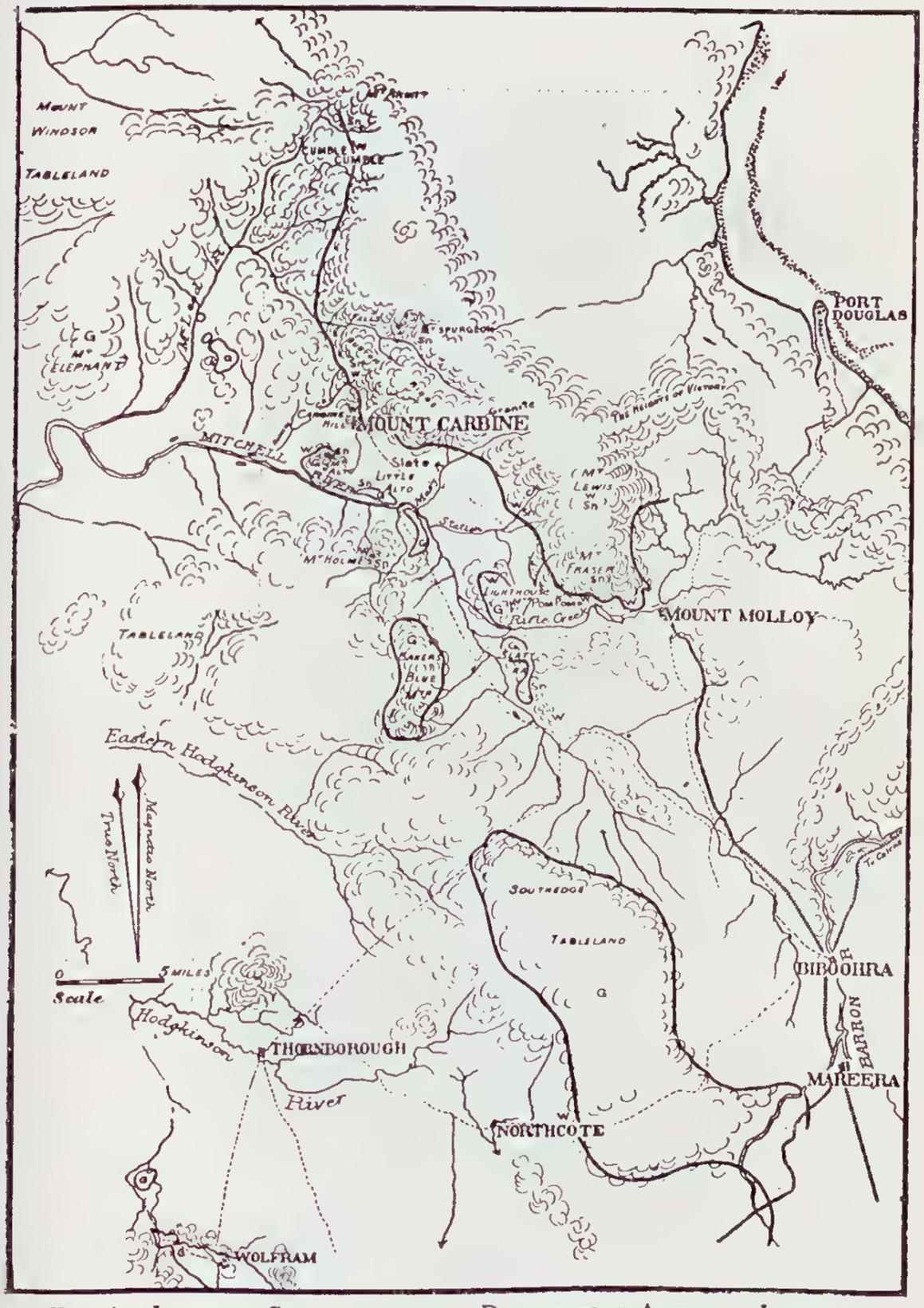

FIG. 1.—LOCALITY SKETCH, ROUGHLY DELINEATING AREAS OF INTRUSIVE GRANITE.

all its leases, but it is by far the greatest of the producers, the output of the five claims worked by parties independently of the company being negligible. The number of men on the com-

pany's pay sheets in the latter part of 1912 was 90, this including 30 miners. There is a regular loss and gain of 10 or 12 men per month, many of these floating units of the population coming to the mine more for experience than for immediate pecuniary gain.

PHOTO. 2.—MOUNT CARBINE TOWNSHIP AND THE SOUTH-EASTERN END OF CARBINE HILL, WITH THE BURTON RIDGE IN THE BACKGROUND.

Early in 1906 the population of the town was 110 people. In 1907 there were employed 150 men in the vicinity; but in the following year the workers had dropped to 40 or 50 men, the

number increasing again in 1909 to 70. In 1910 the total population rose to 350, and culminated in 1911 with 500, for during 1912 it fell again to 400.

Literature.

There has been in the past a somewhat remarkable silence concerning this field, and even now the news filters through with inexplicable slowness.

The subjoined paragraph from Mr. Dunstan's progress report* for the year 1904 is the first official notice of Mount Carbine that I have been able to find. This is part of a résumé of the conclusion drawn from the field work of that year.

"Mount Carbine, a comparatively new and little-known field, is situated about 30 miles in a direct line north-west from the Mareeba Railway Station, but along the road is about 50 miles from Biboohra, *viâ* the Mount Molloy Copper Mines. The wolfram occurs in a large number of quartz lodes, and the prospecting work has indicated the permanence of both the lodes and their wolfram contents. The field is destined to become an important one in future."

Since Mr. Dunstan's visit Mr. Sydney Horsley, Inspector of Mines, has briefly reported on the field on several occasions,† and since July, 1909, the Warden stationed at Herberton has made passing mention in his monthly reports published in the "Queensland Government Mining Journal."

There was a paragraph in the "Australian Mining Standard" of the 29th March, 1911, on this field, and each issue of the Annual Report of the Department of Mines since 1904 has had a passing reference to the locality.

Acknowledgments.

I desire to here express my grateful appreciation of the courtesies extended to me at Mount Carbine by the Irvinebank Company. Mr. J. M. Reid, representing the General Manager, placed the office at my disposal, and his instructions to his officers to give all help required were loyally carried out. The local manager, Mr. F. C. West, besides conducting me over his own mines, spent a good deal of time in the field with me on geological and mine examinations.

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* See Annual Report of the Department of Mines for 1904, page 150.

† See "Queensland Government Mining Journal" for 1906, January, July, and October; and for 1907, March.

Mr. O. H. Woodward, the company's surveyor, kindly prepared tracings of his plan of the chief workings for my use, and I was also given the opportunity to make copies of others of the fine series prepared by him. In the office much assistance was ungrudingly given me by Mr. A. Burton, the accountant, who also acted as my guide on several occasions.

Mention of all others who proffered aid would not be practicable here, but acknowledgment will be made when possible in the body of the report.

GEOGRAPHY.

The want of a large scale topographic map of this district is a serious handicap in the elucidation of its geological structure; and at present we are restricted to the 4-mile sheet published by the Lands Department. This is seriously lacking in detail, and many of the features are incorrectly delineated, as is to be expected of unsurveyed country.

Location.

The wolfram workings cover and penetrate an isolated hill in the valley of the Mitchell River, which hill is now commonly known as Mount Carbine, even though the State 4-mile map so indicates one of the Heights of Victory, quite 8 miles to the east of the workings, and 14 miles west of Port Douglas. Some confusion might be avoided by calling the former Carbine Hill, as below.

PHOTO. 3.—MOUNT CARBINE FROM MOUNT ALTO, WITH INTERVENING DRY VALLEY AND BURTON RIDGE IN BACKGROUND.

Mount Carbine township has been surveyed between the southern flank of the hill and the right bank of Manganese Creek, a small tributary of the Mitchell.* The population of this centre

* Its exact position is, according to the 4-mile map: Lat. 16° 31½′ South, and Long. 145° 8′ East.

is about 400, including children and a not inconsiderable floating element. There are three hotels, the usual stores, a school of arts, a church, a school-house, a court-house and a hospital, besides a number of private houses, huts, and tents.

Port Douglas, 16 miles distant in an air line from Mount Molloy, which is 24 miles by road from Mount Carbine, is the natural port for Mount Carbine, and in the early days of the field all supplies came thence *viâ* Mount Molloy, but, with the opening of the Biboohra-Mount Molloy Railway in 1908, Cairns became the distributing centre of the whole of the tableland. From Cairns to Biboohra by the State railway the distance is 41 miles, and from Biboohra to Mount Molloy by the Mount Molloy Company's private line is 20 miles, the total railage being thus 61 miles. The coach road from the terminus to the mines is but a narrow track, much cut up and exceedingly dusty at all times but the wet season, when it becomes correspondingly boggy. The two lines of coaches running back and forth three times a week easily cope with the passenger traffic; but goods are transported by teamsters.*

Physiography.

The valley of the Mitchell above its junction with the McLeod exhibits topographic forms of some complexity—features of juvenile aspect having been superimposed on others decidedly mature. The wide flat floor of the valley and the rounded forms of the hills point to age, but the precipitous faces of the range to the north, with their numerous waterfalls and hanging valleys, are youthful features, as is the absence of meanderings in the river itself. Near the head the valley is without relief, but lower down precipitous slopes are the rule, and the course of the river exhibits many puzzling features, the stream in several places having apparently left a wide flat-bottomed valley and cut its way through high ranges. The key to the situation lies in the geology of the valley, and when it was found that slates form the beds of the streams and that the higher hills and ranges are all granite, the assumption arose that the river is much older than the ranges among which it winds, and that these ranges

* The following are the transport costs and charges per ton of concentrate from Mount Carbine to Cairns :—

	£	*s.*	*d.*
Bags	0	12	6
Bagging	0	1	0
Loading (Mounts Carbine and Molloy)	0	2	0
Cartage (Mount Carbine to Molloy)	2	0	0
Railage (Molloy-Biboohra)	0	8	5
Railage (Biboohra-Cairns)	0	11	6
	£3	15	5

would have long disappeared by denudation had they been built wholly of slate, the surviving mountains owing their preservation to their superior resistance to the agencies of denudation.

The river rises in the sandy flats within a few miles of Mareeba, and for several miles flows northwards parallel to and within two miles of the much larger Barron River.* It then

PHOTO. 4.—MOUNT CARBINE FROM THE NORTH-EAST, WITH MOUNT ALTO IN THE MIDDLE-DISTANCE.

trends off to the north-west, flowing through country of low relief until old Northedge homestead is reached, when it passes among the denuded remnants of an old range (the Slaty) and is thrown slightly out of its course. After a few miles it resumes its even journey to the north-west, with high ranges within a mile or two to the right and left almost to its junction with the Mary River, where it makes another sudden bend to the west-north-west and cuts through still another range (Little Alto). Below this the river is confined by ranges on both sides, yet a little way to the north is a parallel flat-bottomed valley, the elevation of which is not much greater than that followed by the river. (See Photo 3.) The township of Mount Carbine is in this valley.

While I have not spent sufficient time in the field to decide the matter, and, though they are not so shown in the attached

* For notes on the past history of the Barron River, showing that the Upper Barron was probably once the head of the Mitchell, see "Notes on the physiography of North Queensland," by W. E. Poole. Australasian Association for the Advancement of Science, 1909, p. 316.

diagrams, I am inclined to regard the Heights of Victory between Mounts Fraser and Armit as block mountains, evidence of faulting in the ranges themselves being by no means wanting. At the same time the equilatitudinal eminences known as Mount Holmes, Baker's Blue Mountain, and Mount Elephant, might be cited as evidence of a former high-level peneplain; and there is a defined plateau between the valleys of the Mitchell and Hodgkinson

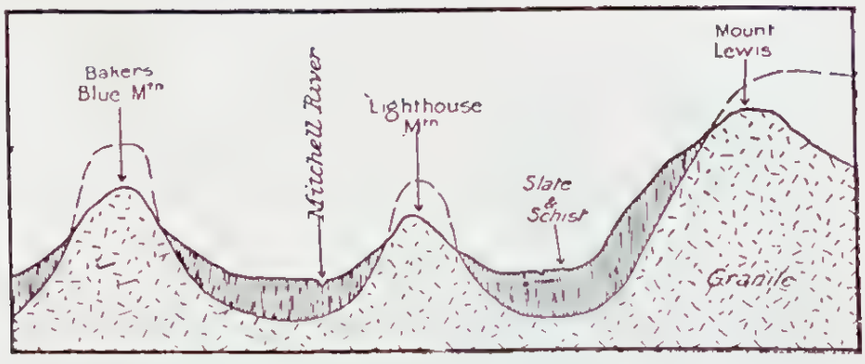

FIG. 2.—DIAGRAMMATIC SECTION ACROSS MITCHELL VALLEY, Between Carbine and Molloy.

Rivers at a slightly lower elevation. The Burton Ridge, to which further reference will have to be made, is a spur of the Heights of Victory overlooking the township of Mount Carbine and separating the valleys of the Mitchell and McLeod Rivers. This, in my opinion, is a slightly down-faulted fragment of the Heights of Victory block.

The isolated mountains are simply mountains of denudation, the slates of the valley having succumbed at a much faster rate than the granites of the hills. The cycle of denudation is just now at an interesting stage, most sections across the valley being of the form illustrated in the diagrams below. In these it will be seen that all the granite hills are lapped round by sedimentaries; and it is believed that a granite peak is still covered by the slates of Mount Holmes. (See Fig. 3.)

ELEVATIONS.

My aneroid measurements indicate the township of Mount Carbine to be a little over 1,000 ft. above sea level—*i.e.*, about 150 ft. below that of Mount Molloy or 200 ft. below Biboohra, the elevation of which is 1,260 ft. above sea level.

Carbine Hill rises 500 ft. above the township, being completely overlooked by the Burton Ridge, which rises to 2,700 ft. above sea level and is itself over-topped by Mount Spurgeon, of which the elevation is 3,500 ft. The summit of Mount Alto is 1,250 ft. above the township.

Water Supply.

During the short periods of flow, that is only immediately after heavy rain, the town supply is drawn from Manganese Creek. A more permanent source is in the sands and gravels of the old bed reached by shafts sunk on the flats near the banks. The company's well above the dam has not yet failed, but the town well below gives out towards the end of the dry season; and, prior to the sinking of the company's well, water had to be carted from the Mitchell River, a distance of four miles.

In order to conserve a supply for the mill the company built a dam across Manganese Creek, but this is rapidly silting up and was practically dry in November last, when the mill was depending on an adjacent well. The dam is of concrete, and a great expense was incurred on its construction, because, though rock crops at the western end, the foundations were 34 ft. deep at the eastern end; and a puddle wall had to be run out into the adjacent flat for a distance of over 4 chains, the average depth of clay and sand being nearly 35 ft.

The Mitchell River is fed by several perennially running streams, including Rifle Creek, Station Creek, and the Mary River, all rising in the coastal ranges; and the flow opposite Mount Carbine is probably over 10 million gallons per day. The cost of pumping water from here to the township would not be excessive, as the difference in elevation is only about 150 ft. Alternatively a supply might be brought in either from the Mary River or from the McLeod. The nearest point of the Mary is five miles from the mill, and the intervening country is not at all rugged, but to obtain a head it would be necessary to continue the pipe line some distance up this river.

The McLeod Falls are four miles north of Mount Carbine, but the line would have to be brought round the end of the Burton Ridge, and the total length of piping needed would be at least eight miles. The top of the falls is not far short of 1,000 ft. above the mill, and, as the stream carries probably 5,000,000 gallons per diem, there is more than sufficient for all requirements, including power production. This is a fascinating proposition, but the capital outlay required could not be justifiably incurred without greatly augmenting the reserves of ore in the mines.

The re-use of a part of the mill water has been rendered possible by the addition of the boiler ashes as a precipitant, but the quantity of wood ash is altogether inadequate for requirements, and at times the water returned to the mill is not so clear as could be desired.

Timber Resources.

The country in the vicinity of the township was never very thickly timbered, but recent demands for fuel are causing almost complete deforestation of parts, consequently the cutters are

PHOTO. 5.—LOOKING SOUTH FROM THE MILL OVER THE TAILINGS' DAM; MOUNT FRASER IN THE DISTANCE, CLOUD-CAPPED.

naturally increasing their distance from the mill, and thereby is caused an all-round increment in the cost of power production. Stunted varieties of box, sandalwood, and beefwood are the most common timber trees on the flats, but they give way on the

ridges to narrow-leaved ironbark and bloodwood. Tea-tree of small size is very abundant in the parts that during the wet season are converted into swamps, and pandanus grows in the beds of most of the creeks. On the sides of higher ranges cypress pine has gained a hold; above this belt casuarina appears, and above that again, on the edges of the highest plateau to the north-east of Mount Carbine (the Heights of Victory) messmate, scented gum, and blackbutt grow to large size, but in localities at present inaccessible to the timber-getter.

The Heights of Victory, owing to their elevation and proximity to the sea, are favoured with constant rains, and so are mostly covered with dense tropical vine scrubs or jungles. They at the same time seem to screen off and deflect the moisture-bearing sea breezes from the ranges across the Mitchell to the south of Mount Carbine, for most of these are completely bare of timber.

A few large river gums grow along the Mitchell River, but the timber trees do not flourish along it to the extent that might have been expected.

AREAL GEOLOGY.

The upper portion of the valley of the Mitchell River is a mineralogical province characterised by the occurrence of tungsten and tin-bearing pegmatites in altered sedimentary rocks near their contact with intrusive granite. The surface distribution of this latter rock is interesting, and when the areas have been mapped they are seen to lie in three nearly parallel lines, along which are strung numerous wolfram and tin workings.

Schist and slate are the enclosing rocks of the ore deposits at Mount Carbine, but the always present intrusive granite approaches within half a mile of the workings, and I anticipate that it will be met in sinking within a few hundred feet of the mill level. It remains to be seen whether the veins carry payable values below the sedimentaries. It is almost certain that the veins will continue some distance into the granite, and they should have been so delineated on the accompanying section. (Fig. 3.)

Slates.

The much altered sedimentary rock of Carbine Hill is fine-grained and from a little distance resembles massive slate, but close examination reveals a laminated schistose structure. The laminations are sometimes exceedingly regular and closely spaced, but at others so widely apart that it is then difficult to decide whether the rock should be designated slate or schist. Crumpling is rare and was noticed only in the vicinity of a few of the fissures. The laminæ are lustrous, owing to the separation of a dark secondary mineral of micaceous habit; and generally the development of the schistose structure has been accompanied by the production of abundant crops of the secondary mineral ottrelite, which, with the incipient augen-structure observable in many places, is evidence in itself of regional metamorphism. That the schistose structure was induced in the slates prior to the deposition of the vein minerals is proved by impressions of the laminæ showing on the sides of the veins, the best case to hand being that of the Ruby United.

Towards the northern end of the field a thin-bedded structure predominates, though even there the schistosity is not altogether absent from certain beds, until in the vicinity of Holmes Creek, where, as for example at the Redcap, the slates become epidotic and massive.

The planes of stratification and schistosity do not, as far as known, differ, their dip approaching the vertical wherever observed and their strike varying seldom more than 20° east and west of north on Carbine Hill.

The Mount Carbine ore deposits do not follow the lines of bedding or schistosity, as might have been expected, but cut obliquely across them. The country in the vicinity of the ore-bodies is, as a rule, quite unaltered, except in a few places of more intense folding, where thin seams of granular quartz may be noticed along the laminations—as in the inner end of the mill adit.

There are nevertheless several zones or areas near Mount Carbine where silicification has been intense, the slate having been changed into a horny or cherty rock, but these are either outside the ore-bearing country (to the south-east or north-west) or else in the poorest parts (to the north-east). The silicification must have been brought about by the agency of capillarity, the silica having been derived from the cooled intrusive emanations. It is therefore likely that wolfram-bearing veins will be found beneath these silicified areas, and the occurrence of manganese ores at Sundets gossan blow lends some support to the theory. The siliceous nature of the schists in the inner end of the mill adit is to be ascribed to this agency rather than to direct impregnation during ore deposition.

Felsite Dykes.

A porphyritic felsite dyke, sometimes showing fluxion structure, extends across the hill from south to north for a distance of a little over a quarter of a mile. The trend is slightly sinuous, so that it cannot be said to follow the bedding of the country, though in places it does not depart far from it. The average thickness is 20 ft. with few constrictions, and it tapers out abruptly at either end. Mr. Hetherington informs me that the Ruby United reefs have been heaved several feet by the dyke—an interesting point that I could not verify because of caving of the workings.

Some five chains beyond the northern end of this dyke there is another outcrop of the same rock, and this extends away to the northwards with great variations in width—in one place it is two chains wide and nearby only six feet. The fluidal structure is so perfect in parts that a perfect fissility has resulted in the rock.

A third dyke of a felsitic rock forms a small peak near the granite contact about a mile to the north-east of Mount Carbine.

These dykes do not seem to have any important bearing on the origin of the wolfram deposits and most likely are younger.

Intrusive Granite.

While examining the wolfram mines a number of hitherto unmapped areas of intrusive granite were observed. There is a possibility of all those in the Walsh and Tinaroo district being of the same age, but for the present it will be advisable to confine the discussion to those of the Mitchell Valley, wherein

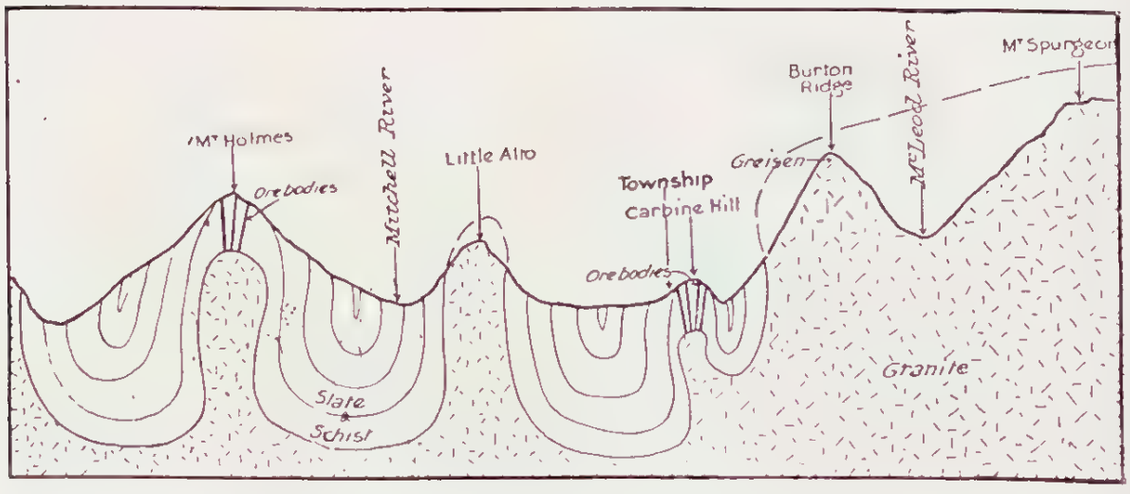

Fig. 3.—Diagrammatic Section through Carbine Hill and across the Mitchell Valley.

there are three distinct but parallel lines of outcrops; one along its north-eastern divide, another along the south-western divide, and a third extending along the centre of the valley. The granite in each case stands high above the slates, because of its superior resistance to the weather; but in all cases the foothills are slates as shown in the accompanying sections. This is probably an effect of contact metamorphism, the slightly indurated rock being more resistant than the unaltered slate distant from the contact.

A study of the grouping of the granite outcrops leads to the conclusion that a number of parallel batholiths have been partly exposed, and further that these occupy anticlinal loci in a series of great earthfolds produced by forces acting from north-east and south-west. For the present we are concerned with those of the Mitchell Valley only, but it may here be mentioned that there is evidence of a continuation of the folding far out to the west (to Chillagoe at least). The north-eastern *massif* is well exposed, and all the peaks on the central show, but some of those on the south-western line have not yet been uncovered.

As to the nature of the rock itself, it is a tenary quartz-orthoclase-biotite-granite, of medium texture (varying slightly from place to place) and in many parts exhibiting a well-defined

PHOTO 6.—CHARACTERISTIC WEATHERING OF GRANITE, SUMMIT OF MOUNT ALTO.

porphyritic structure. The strong joints by their control of the direction of weathering have resulted in most of the granite areas being strewn with boulders, the undecomposed kernels from between the joint planes.

NORTHERN AREA.

The greatest of the *massifs* is that first mentioned, extending as it does from near Mount Molloy on the south to Mount Windsor on the north, and including Mounts Fraser, Lewis, Spurgeon, and Armit. It stands out as a bold range, rising quite abruptly to an average height of 2,500 ft. above the valley floor. The contact of the granite and slate usually runs along the foothills, and only in a few places does the granite extend out on to the floor of the valley.

A little muscovite-bearing granite caps the Burton Ridge (on the track to Mount Spurgeon and at the Vera Tin Mine) indicating the former existence of a sedimentary cover nearby, but otherwise true greisen has not been formed on the contact of the intrusive and the older sedimentaries. The vicinity of the contact has nevertheless been a favourable locus for the accumula-

tion of tungsten and tin ores. In the fringing sediments wolfram deposits have been opened in the vicinity of Mount Molloy, Pom Pom, Station Creek, Mount Carbine, and Cumble Cumble. In the granite the same ores have been worked at several places, to

Photo. 7.—Mount Alto from the Gems United. The upper half of the Mountain is granite, the lower slate.

mention only Mounts Fraser, Lewis, Spurgeon, and Armit, along the summit of the main range; at the Vera on the Burton Ridge; and at Pianto's on Manganese Creek to the north-east of Carbine Hill.

Biotite granite is exposed on the surface within half a mile to the east of the main workings on Carbine Hill, but whether this is an inlier or simply the extremity of a tongue coming down from the Burton Ridge has not yet been determined because of the soil mantle along Manganese Creek and its tributaries. More than a dozen reefs from 1 to 6 ft. in thickness crop out on the surface, most of them consisting of barren quartz, though a little felspar was noticed in one and traces of wolfram and tinstone also are showing.

A quarter of a mile to the north of Pianto's biotite granite again crops, and here also numerous parallel quartz reefs and leaders appear at the surface, some of them carrying traces of wolfram and tinstone. This area is definitely connected on the surface with the great *massif* to the north-east.

SOUTH-WESTERN AREA.

On the south-western line there are only three crops—the South-edge tableland, Baker's Blue Mountain, and Mount Elephant; but there is reason to believe that granite lies at no great depth beneath Mount Holmes, which is on this line and is similar to Mount Carbine in geological features.* Wolfram has been worked near Northcote (on the western side of the tableland), at Mount Holmes and at Mount Elephant, but no discovery has yet been reported from Baker's Blue Mountain.

CENTRAL AREA.

The central line 3 or 4 miles south-west of the Coast Range has six distinct crops, on four of which wolfram and tin have been found—viz., Slaty Range, Lighthouse Mountain, Little Alto, and Mount Alto. Slightly greisenised slate has been exposed in the tin workings along the irregular contact on the northern end of Mount Alto.

* See "Queensland Government Mining Journal," November, 1912 p. 541.

ORE DEPOSITS.

The ore deposits, being tabular in form, are almost the sole representatives of their kind in Queensland. At Torrington,* in New South Wales, pegmatite carries wolfram, but the conditions there are not in any way analogous to those of Mount Carbine.

Nature and Genesis.

The veins are bunched into overlapping and slightly radiating zones, of which at least twelve can be distinguished. Each zone includes fissures, which, while preserving on the whole a rude parallelism, frequently branch and in places converge

Fig. 4.

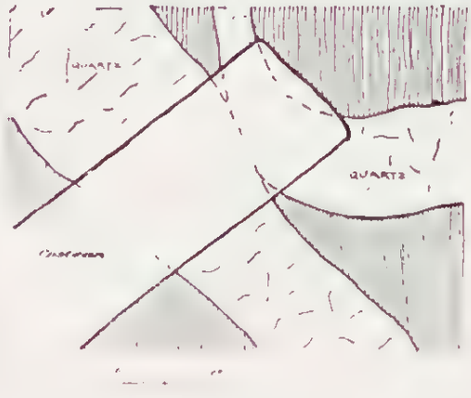

Fig. 5.

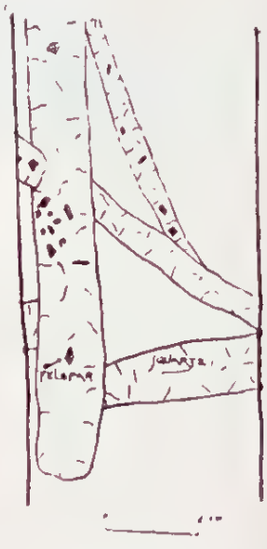

Fig. 6.

Fig. 4.—Details of Branching Vein, No. 2 Drive, Mill Adit, Johnson Lease. Full width of drive.

Fig. 5.—Junction of two Veins, Nil Desperandum. Surface.

Fig. 6.—Nature of Intersections, 221 N.W. Drive, No. 3 Adit, Mount Carbine No. 1. Full width of drive.

sufficiently for anastamosis. The plans of the workings consequently show a network of interlaced parallel veins, as the ore-bodies seldom extend far without branching. Petering out is a constant characteristic of the ore-bodies; but, as an overlapping vein is almost always to be found within a few feet of

* See "Geological Survey of N.S.W. Mineral Resources" No. 15. By J. E. Carne.

the first, a drive may be carried along such a system for hundreds of feet with but few slight variations from the straight line.

They are plainly composite fissure veins or dykes formed in intrusive emanation zones, by which it is meant that the ore-bearing solutions after expulsion from a solidifying granite magma (of which they were residual products) forcibly intruded the overlying rock under disruptive pressure,* and were later precipitated along the fissures resulting therein. The cognate veins in the granite to the north-east of Carbine Hill lie parallel with those of Mount Carbine; but it is noticeable that they do not continue into the overlying slates, which, however, are highly

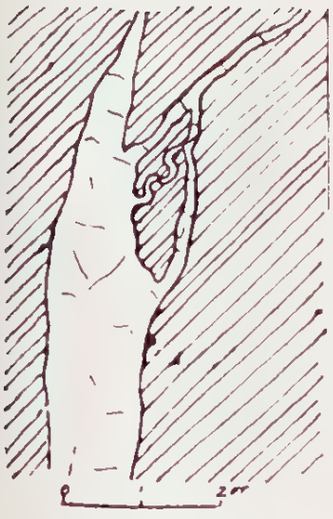

Fig. 7.

Fig. 8.

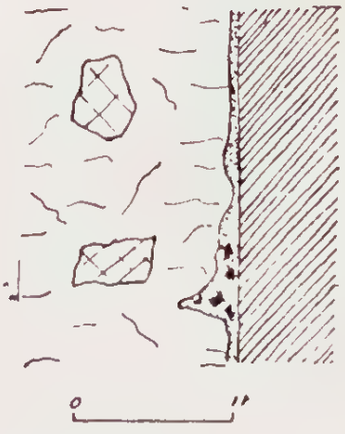

Fig. 9.

Fig. 7.—Fraying out of Vein, No. 6 S.E. Drive, Mount Carbine No. 1.

Fig. 8.—Splitting up of Vein; Face, No. 2 Adit, Johnson Lease.

Fig. 9.—Micaceous Selvage between Vein and Wall, No. 1 Adit, Mount Carbine, No. 1.

silicified. The intrusive emanations were presumably here deficient in disruptive power owing to rapid cooling; and the silicification of the overlying slate is to be ascribed to subsequent capillary action.

It is noticeable that where the slate and schist have been much fissured, as is the rule on Carbine Hill, the bedding or

* The Laws of Igneous Emanation Pressure. By Blamey Stevens. Trans. Am. Inst. of Mining Engineers. Bull. No. 64, page 411.

joint planes have never been followed by the solutions. Where, however, as in Scheelite Gully, the fissuring has been imperfect, the veins are located mostly along joint planes, and some spurs also run off between the laminations of the country to which they are tightly "frozen." In general there has been no replacement of country rock, and the pegmatites are everywhere

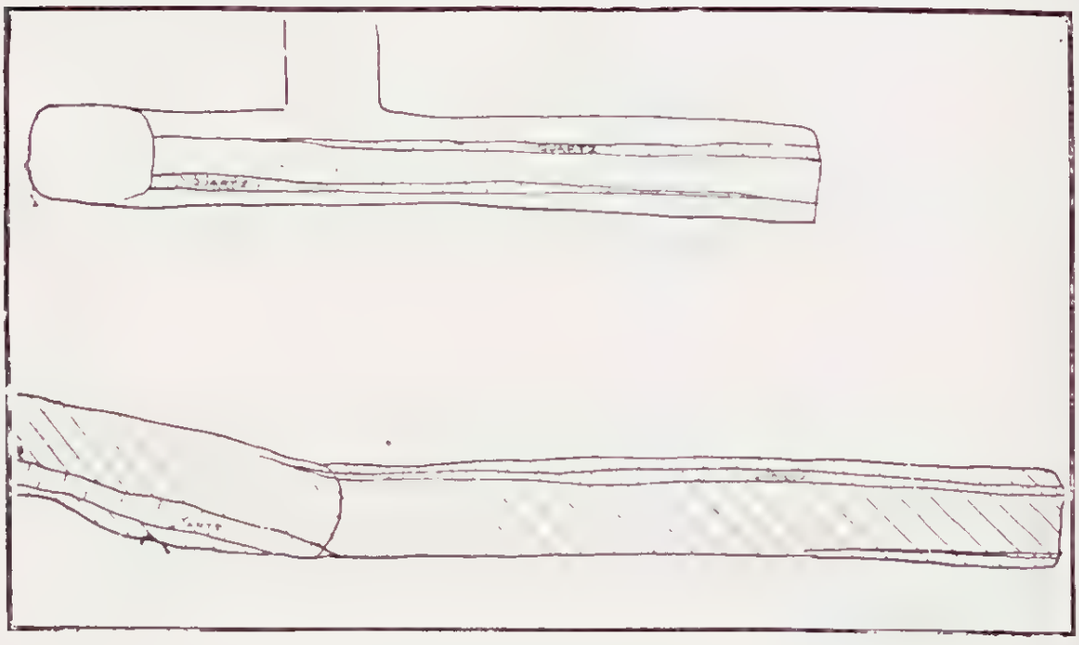

Fig. 10.—Overlapping Veins in Adits on Daisy United.
(Scale 11 ft. to an inch.)

sharply divided from the walls. Such small quartz leaders as those mentioned above, which have become attached to the walls (owing to replacement of the adjacent rock by silica) are comparatively rare.

The walls have a most distinctive undulatory contour, where not broken by joints and faults. In the D.C.L. stope there are frequent sharp juttings out as though step faulting had occurred, while yet the general surface is a rounded or swelling one.

The fissures are mostly clean, and the lode material free from inclusions, but exceptions to the rule were noticed in several places, particularly in the end of the mill adit and in the overlying 180 E. drive from the No. 3 adit, and also in No. 1 adit and in Cassel's upper working on the Johnson.

Apparent faulting is not at all uncommon (see the Iolanthe, Ruby United, Johnson, &c.), but the heave is never great, and most of the faults or joints are older than the reefs. In one or two cases the proof is demonstrated by the vein following the crosscourse (see the Jubilee); and in still others some veins cut

off on cross-heads while neighbouring ones pass through without injury (see Johnson mill adit). It is believed by some of the claimholders that breaks are more frequently met towards the surface than in the deeper ground.

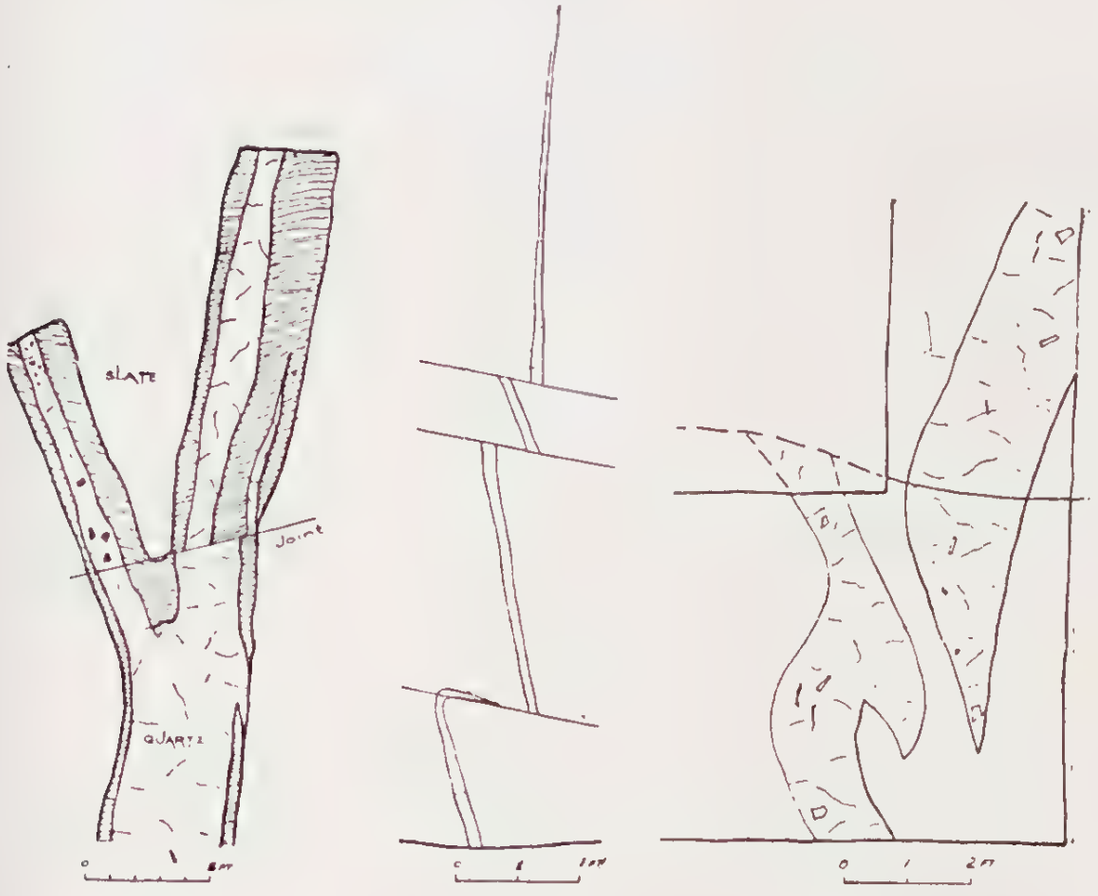

Fig. 11. Fig. 12. Fig. 13.

Fig. 11.—Details of Faulting, Branching, and Pinching, No. 2 N.W. Drive, Mill Adit. Full width of Drives.

Fig. 12.—Step Faulting, Last Call.

Fig. 13.—Overlap and Fault, Shaft on Adit, Nil Desperandum.

Extent.

The ore-bearing slate country has a length of 1½ miles from south to north and a maximum width of ¼ mile. The veins, however, trend north-west and south-east, or thereabouts, in a parallel direction to the escarpments of the Heights of Victory.

The veins vary in size from mere threads up to bodies 6 ft. wide, but those now being worked are mostly less than 2 ft. thick. They are best developed both as to number, size, and richness in the south-eastern part of the hill between the mill and the felsite dyke. As they near the mill they rapidly thin out into leaderlets (which still carry wolfram); and beyond the dyke they are much less numerous and poorer than on the near side.

Floater Ground.

The "floater" ground is one of the puzzles of Mount Carbine. It is a surface accumulation of quartz fragments derived from the lode crops, but the curious feature is that it does not follow the crops nor yet the gully beds, instead running out in two main streams from opposite sides of the hill, one down and across Bock's Gully and the other down Petersen's Clayey Gully. The fragments are quite angular and without any binding except a little dusty earth, and the only explanation that at all fits the case is that they have been produced by landslips in the distant past. The stripping is sometimes 10 ft. deep, but more commonly bedrock is met within 2 to 5 ft. of the surface.

ORE.

For convenience of discussion the minerals of the ore-bodies will be separately classified as: gangue, here the valueless part; associated metallic minerals, or more properly speaking those being or likely to be worked for their metallic contents; and the tungstates.

The gangue is extremely variable in composition. Some veins are wholly of quartz, and in some parts of others felspar forms the greater part of the ore, but, generally speaking, the vein material is a quartz-felspar rock, in which the amount of quartz is many times greater than that of the felspar.

Wolfram is now the only product, except a little scheelite, for the traces of molybdenite and tinstone found at one or two spots have not been saved.

Gangue.

Quartz is the chief gangue mineral. It is massive crystalline, but distinct crystals are never seen in the main veins. The sole place in which crystals of quartz, drusy in cavities, were observed was on Macdonald's claim in the north-western part of the field, but other conditions are abnormal there also, and it certainly is the case in the producing mines that the mineral is never crystallised. It breaks, as a rule, with extremely sharp edges, which are a constant source of danger to the miner, whose hands are frequently lacerated. The strongly fetid odour emitted by fresh fractures might lead one to expect blood poisoning, but I am assured that, on the contrary, the healing is very rapid. A bluish slightly opalescent variety of quartz is found in a few of the veins, but though it has been known to carry wolfram it is not regarded with favour by the miner.

Scattered through the quartz are allotriomorphic masses of orthoclase (*felspar*) of all shapes and sizes and in all degrees of abundance. Some parts of the veins are chiefly composed of felspar, but frequently it is quite absent; and from end to end it will probably not exceed 10 per cent., while it may be as low as 5 per cent. of the whole gangue. The felspar and quartz are often banded parallel to the walls, and frequently the felspar is concentrated near the central plane of the veins, but more often there is a complete lack of any definite structural arrangement.

Muscovite (*mica*) is present in the body of the quartz in very few of the veins. The most conspicuous case is that of the Bobby Dazzler (in the northern corner of the Johnson lease); and another is that of the tributer's vein on the Little Nell; but the most noteworthy occurrence is that on the main Johnson vein at the face of the south-eastern drive off No. 2 adit. There the gangue consists of quartz with undecomposed felspar and enough muscovite to give it the aspect of greisen. It may here be of the same generation as the pegmatite; but in various other parts of the field a little feathery muscovite may be seen coating the walls of veins (*e.g.* in the Nil Desperandum adit), and in these it is to be regarded as a decomposition product of the felspar, for it is usually accompanied by kaolin, and occurs only high in the zone of oxidation. Along a vein near the inner end of No. 1 adit on the Mount Carbine No. 1, which vein is of quartz with some felspar towards the walls, there is an irregular lining of kaolin and mica up to ½ in. thick, and this carries a little wolfram. Generally also the miners look upon mica-coated walls as a promising indication of the proximity of wolfram-bearing ore. In the upper level of White's workings on the R.S.B., a new vein rich in wolfram was found by driving from an old stope along a mica seam in the country rock.

Tourmaline is not visible in the veins nor in the country, but each week 6 or 7 bags of a very fine brownish acicular crystalline material is obtained as "seconds" on the Luhrig vanners in the mill, and this was first shown by the company's chemists to be tourmaline.

Greenish-grey crystals of *beryl*, associated with flaky laths of wolfram, micaceous kaolinsed felspar and a little chalcopyrite, were found by Mr. West in the molybdenite leader in rising from the mill adit to the No. 3 adit level. Hand specimens containing the minerals were shown me.

Associated Metallic Minerals.*

In the surface portions of the veins the miners always look upon quartz with reddish stains on cracks as favourable gangue for wolfram. These stains have been formed by the oxidation of *pyrite*, which in the deeper ground occurs as extremely thin seams in the quartz associated with wolfram. The actual amount of the mineral is minute, but its manner of occurrence renders it noticeable. Very slight stains of copper carbonate are seen in the

* Mr. Dunstan, who visited the field in 1904, recorded for the Mineral Index, then in course of preparation, that wolfram at Mount Carbine is associated with molybdenite, scheelite, cassiterite, limonite, chrysocolla, etc.

upper levels in places (especially in the D.C.L. and R.S.B. workings on the Bluff vein); and the primary *chalcopyrite*, also in very slight traces, has been detected below (at the Edith and in No. 2 north drive from the mill adit on the Johnson).

Tinstone is showing in quantity in the felspar of pegmatite in one of the cuts on the old Joseph lease, which is a tungsten-bearing area. The mineral accompanies wolfram also in Pianto's workings in the granite to the north-east of Mount Carbine. Tinstone is being recovered from greisen, pegmatite, and quartz at the Vera, which is on the Burton Ridge at the head of Holmes Creek a few miles north of Mount Carbine, but the ore has hitherto been free from wolfram, the place of which is taken by a little arsenopyrite. Alluvial wolfram has, however, been recovered from gullies adjacent to the Vera.

A little *molybdenite* was obtained by Mr. West from the small vein in the rise from the mill adit to No. 1 adit level, but it did not extend beyond the walls of the opening, and I was unable to see it in situ. Subsequently Mr. West detected further traces in the face of the 180-ft. drive, not far from the rise. Traces of the mineral were observed by me in the concentrate from the Edith; it has been noticed at the Triangle; and one very small patch has been located on the Vera tin claim, surrounded by quartz in granite.

Tungstates.

Under this heading are included two tungstates (that of iron and manganese and that of lime), with the ochre, which probably contains hydrated iron tungstate.

WOLFRAMITE.

The wolfram itself, like the felspar, exhibits no regular crystal habit; although in some places radiating elongated laths have been observed, stumpy shapes are the rule. On the Iolanthe and D.C.L. the wolfram is found in divergent blady crystalline forms; but on the Daisy United line it is more frequently acicular, and much of it is concentrated near the walls, from which the crystals tend to project at right angles, this being also a characteristic feature of the ore on the Felsite Knob. Elsewhere there is no distinctive segregation of the wolfram.

It occurs both in the quartz (particularly where iron-stained) and in the felspar, a slight preference being shown for the latter mineral as a host; and the miner, when he strikes a part of the vein rich in felspar, knows that an improvement in the grade

of his ore should follow. A small fragment of ore, shown me at the Little Nell, consisted apparently of small crystals of wolfram in kaolinised felspar, the effect being much that of a breccia. It is known as speckled ore. The very rich ore in the 209 ft. south drive off the No. 3 adit in the Mount Carbine No. 1 lease also had a felspar gangue.

The largest block of wolfram yet uncovered came from the Bobby Dazzler surface workings, where the vein is rich in felspar and contains also much mica. This weighed 6 tons. One 2-ton block was got in the 180-ft. south-east drive from the No. 3 adit on the Mount Carbine No. 1.

It is noteworthy that no wolfram has ever been found in the country rock at Mount Carbine.

The amount of wolfram present in the company's ore, as determined by the weekly runs of the mill during the past 18 months, averages 1¾ per cent.; but a casual inspection of the mine would give no impression of such a content.* Wolfram can seldom be seen in the faces left standing, there having been always a tendency to push ahead as long as metal was showing. The always more or less bunchy occurrence of the ore accounts to some extent also for the poor showing at times, and it is only by keeping a number of faces advancing with the object of sooner or later breaking into all such bunches that the average can be maintained. That the surface stone must have been somewhat richer is proved by the fact that the tails from the sluicing done prior to the erection of the battery contained 1·1 per cent. wolfram as fed into the Huntington mill for re-treatment.

The "gougers" gauge of specific gravity is the 1-lb. tea tin, which is 4¼ in. cube, and the greater the weight of a tin full the higher grade the wolfram is considered, 14 lb. being the maximum. Some of the Carbine wolfram (Iolanthe) is said to weigh only 10 lb. to the tin, but the Little Nell runs 12 lb. It has been also been noticed that the coarser the grain of the concentrate the higher the specific gravity, there being a difference of ½ to 1 lb. per tin in favour of the grains ½ in. in diameter as against fines. Further, Mr. West assures me that the wolfram from the deeper ground is certainly of greater specific gravity than that from the surface. These facts are probably to be accounted for by the perfect cleavage of the mineral resulting in open partings during weathering or crushing.

* That poorer ground than usual was being worked during my inspection was shown by the weekly yield falling to 4 tons (1·37%?), the usual being about 5 tons. Very exceptionally 9 tons (2·85%) had been bagged. Three rich patches were struck simultaneously just before my departure.

Analysis.—For the following analysis of "typical Mount Carbine wolfram concentrate," made by Mr. Alex. Cumming at the Irvinebank Compay's assay office, I am indebted to Captain J. M. Reid. From the analysis the composition has been computed of the theoretical pure iron manganese tungstate,† the chemical formula of which should be written (3FeO. MnO) WO_3 the mineral being therefore wolframite nearer ferberite ($FeWO_4$) than hübnerite ($MnWO_4$):—

Insoluble SiO_2, etc.	4·0		
Tungstic acid	71·2	= 74·8	Pure.
Copper	0·2		
Bismuth	0·1		
FeO	18·0	= 18·9	
MnO	6·0	= 6·3	
Undetermined	0·5		
	100·0		

The company's assay books show that during 1911 (when the average was 71·4 per cent.), the company's concentrate sometimes contained as low as 69 per cent. WO_3, but during 1912 the percentage was never below 70, and in some parcels it reached 73·5, the average being 71·6. The hand-treated ore purchased from outsiders, on the other hand, has fallen as low as 65 per cent., but more usually varies between 69 and 72 per cent.

SCHEELITE.

Scheelite was a constant associate of the wolfram obtained from the gullies along the eastern side of the hill, one of which gullies is named after the mineral. Small quantities of the ore are still won by fossickers working intermittently in this gully. One parcel of 4/20 ton was got from the Wayback early in 1911; and the Little Nell and Edith concentrates contain a small but noticeable percentage. A sample of scheelite from Mount Carbine was assayed for Mr. Dunstan in 1905 as below:—

CaO	=	18·8 %
WO_3	=	77·5 %

Recasting this to pure calcium tungstate we get—

CaO	=	19·5 %
WO_3	=	80·5 %

which agrees approximately with the formula $CaWO_4$.

My opportunities for observing the occurrence of the mineral were very few, and no direct evidence was obtained as to whether

† Dana states that in wolframite the rates of Fe : Mn = chiefly 4 : 1 and 2 : 3 but varying from 9 : 1 to 2 : 1, with hubnerite nearly pure $MnWO_4$ and ferberite $FeWO_4$.

it is an original constituent of the veins. As, however, it occurs chiefly crystallised, and as it does not persist in depth, the probabilities are in favour of its being a secondary mineral produced in calcite-bearing country consequent on the decomposition of wolframite.

TUNGSTITE.

The wolfram now being obtained near the surface on the Iolanthe, X-Rays and R.S.B. (that is, in the Iolanthe and Bluff zones) is much stained by tungstic ochre or tungstite, but there is no evidence of large quantities of that mineral having been produced in this locality.

It is most probable that the ochre includes the lately recorded* new mineral ferritungstite (a hydrous iron tungstate) but it has yet to be examined.

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* Mineralogical Notes by W. T. Schaler, U.S.G.S. Bull. No. 509, p. 83.

MINING.

The Mount Carbine workings, in comparison with those at Wolfram Camp, cover an insignificant area; and, the wolfram being evenly distributed, the returns were never on the fortune-making scale of the latter place, where many very rich finds were made. Perhaps it is for this reason that the Irvinebank Company has been able to secure a firm footing and to attack the problem of winning the ore in a systematic manner, with the result that the weekly output is now comparable with that of the much older and more extensive field.

The Cairns hinterland is in a chronic state of labour shortage and unrest, and the comparative inaccessibility of Mount Carbine (it being off the railway and naturally in a cul-de-sac) places the employer at a serious disadvantage in securing the necessary complement of men as against more fortunately located mines.

There seems to be no complaint as to working conditions here, beyond that of the slight discomfort caused by the comminution of the ore when broken down; and little trouble is experienced with the older men, whose habitations are beginning to show some signs of permanency. That the younger men, however, find a want of attraction in the township itself is not altogether to be wondered at, and the number of changes in the pay roll each month is an expression of their dissatisfaction with living conditions. Before any great and permanent expansion of the mining industry can take place the management will probably have to look into the question of the housing and general welfare of the employee.

Surfacing.

The earliest mining consisted simply in collecting shoads—a means of gaining a livelihood not yet totally discarded. As showing the ease with which cheques were made in the early days, Mr. West told me how, when he took charge, he set a boy to collect "specimens" (*i.e.*, fragments of quartz showing wolfram), and the stone collected during the first month alone yielded ¾ ton wolfram (about £60 worth). This, it must be remembered, was after scores of men had worked over the ground.

The floater ground is usually tested by taking out a small "paddock" a few yards wide and perhaps half a chain long. The ground is loose enough to be broken down by the pick, but

it is further disintegrated by means of explosives in boreholes put down ahead of the paddock. As the face advances, the larger lumps of more barren-looking stone are built up into a wall 3 or 4 ft. back from the face, and behind it the smaller material (including the fines that carry very little wolfram) is thrown after any " specimen " stone has been set aside for future treatment by bucking board or dolly and jig.

The richest of the ground has long been worked out, but there are still a few men working between Bock's Gully and the township. The stripping is mostly less than 5 ft., but Johnson has a face 10 ft. high, and this he estimates to carry 1 per cent. wolfram.

A not inconsiderable part of the production until recently came from the old mullock tips, which in the case of the richer ground have been turned over and over several times by

PHOTO. 8.—FLOATER GROUND, BOCK'S GULLY.

successive parties. The practice seems to be regarded with some contempt; so it is now seldom resorted to except in case of extreme need, and a new term, " lousing," has been coined for the proceeding. At Mount Carbine all the tips contain a little wolfram; many of them may be confidently expected to yield a minimum of ½ per cent. wolfram; and they will all surely sooner or later be passed through the mill. A great part of the Mount Carbine No. 1 open-cut dumps have already been treated, and

preparations are now being made to put through the No. 1 adit dump, a rise having been put up from No. 3 adit to serve as a pass.

Mining Methods of Prospectors.

The mining methods of the first prospectors were primitive in the extreme, the favourite procedure being to attack the crops on the hillsides as though intending to run a tramway cutting across the hill. By this means hauling was obviated, all waste being run out to the dump on wheelbarrows. Some of the cuts are 20 and 30 ft. deep, but the trenches or cuts are seldom more than 6 ft. wide, most of them being only half that width, for wherever possible the veins were followed and worked out separately even when only a few feet apart. Subsequently shallow shafts were sunk on a few of the claims, and a little stoping was carried out. At the northern end of the field, where the hillside slopes very steeply, a preference was shown for short adits, of which there are several placed both along the reefs and across country.

Development by the Company.

Th Irvinebank Company, after securing the ground, began to open up the reefs in the south-eastern part by means of adits, of which there are six. Nos. 1 and 3 were put in from the south-western side of the hill to intersect the rich zone on M.L. 2,225 (Mount Carbine No. 1). No. 2, on the eastern side of the hill, proves the zones on the Johnson. Cassell's and Hartley's adits are on the same side, but at slightly less elevation. The mill adit runs from the Combination across the Johnson and beyond into the Mount Carbine No. 1, to a point below the end of one of the southern drives from the No. 3 adit, with which it is connected by a rise. The mill adit is also connected by crosscut, and drive (No. 2) with a winze from Hartley's adit; and it is proposed to continue this drive north-westwards for several hundred feet, in order to make a connection with the No. 2 adit and at the same time open up the Johnson ore-bearing zone.

No. 1 adit is only 40 ft. below the crop of the zone, but No. 3 is 50 ft. beneath No. 1 and the mill adit 30 ft. lower still. No. 2 adit is 120 ft. above the mill adit, Cassell's being 10 ft. and Hartley's 40 ft. below No. 2. The mill adit in the deepest part is 200 ft. below the surface, but beyond the Johnson the hill rises still 200 ft. higher.

No sinking has been done below the mill adit with the exception of a winze from the 189 south-east drive off the No. 2 adit. This is 102 ft. deep, and therefore reaches 70 ft. below

the mill adit. The pressing need for further sinking, driving, and crosscutting is fully realised by the management, but the present is a time of drastic retrenchment with the company, and all expenditure not required for the actual mining of ore already blocked out has been forbidden.

RESERVES.

The calculation of ore reserves in deposits of this kind can be no better than approximations, even when the ground is well blocked out; but rough estimations of the amount of "probable ore" may legitimately be made, where a certain amount of work has been done. Thus, on the Mount Carbine No. 1 and Johnson leases, Nos. 1 and 2 adits afford a nearly complete section through the most productive part of the hill, and Hartley's and the mill adits give a parallel section on the same line 400 ft. away. For the computation it is necessary to know the thickness of the veins intersected, and this is found from the plans to be as below:—

	Total thickness.	Over 18 in.
Section at No. 1 and No. 2 adits ..	44 ft.	15 ft.
Section at Hartley's and mill adits ..	23 „	12 „
Mean	33½ „	13½ „

The average height of the surface above the mill contour may be taken as 100 ft., this being the extent of the "backs."

Hence we have the total quantity of ore 124,074 tons, but ore in veins over 18 in. thick totals only 50,000 tons. Of this nearly 25,000 tons of 1¾ per cent. stone has been crushed, leaving 25,000 tons reserve, which is sufficient to keep the 10 head battery running for eighteen months. During the last two years the stone crushed has been strikingly uniform in grade, the average wolfram content being 1½ per cent. for each year. Over shorter periods the percentage yield has not departed greatly from the same figure; and there is consequently no reason to anticipate any sudden fall in the grade of the ore yet to be won.

This is distinctly not "ore in sight" as it has not been completely blocked out, to do which would be impracticable; but as all factors have been taken into consideration it may be looked upon as "highly probable."*

The surface workings prove the rich ore to extend far beyond

* The official estimate of reserves of ore above the mill level was given me in October last by Mr. J. M. Reid as 50,000 tons of 2% ore, but it was not stated what extent of the ground held was included in this estimate.

the limits imposed by these sections, and there is little doubt that ordinary developmental work will at least treble the reserves above the mill level in the two leases mentioned above.

It is also noteworthy that there is a distinct increase in the totals "over 18 in." in the lower workings—*i.e.*, No. 3 and the mill adit; but, beyond that the 103-ft. winze below the No. 3 adit level was in good ore to the bottom, we are in darkness as to the value of the deeper ground.

Exploitation by the Company.

The system initiated by Mr. West consists in driving along each and every ore-body averaging more than 20 in. in width. Smaller veins are often followed in developing the mine, but unless they are rich the work is not directly remunerative, and even if of higher grade than usual, a vein 6 in. thick cannot be stoped at a profit. Where two or more of the veins approach within a foot or two of one another they may be taken down in one face, and it so happens that it often pays to include comparatively small leaders under those circumstances. Otherwise the walls are seldom broken into except along the roads; and, as the country stands well, remarkably little timber is needed for supports.

A leading stope is carried close behind the face of the drive, and from it the vein is stoped up to the surface. The rill system, by which the ore from the overhead stopes gravitates to the shoots, is in use throughout the mine, so obviating all need for shovelling, and this is one of the chief factors in the successful reduction of mining costs here. Caving of the honeycombed ground is now being provided against by filling the depleted stopes with material sent down passes from the surface.

All drilling is done by hand, a state of affairs persisted in partly because of the extreme narrowness of most of the stopes, but chiefly because the nature of the ore (friable quartz and felspar) renders the drilling comparatively easy, 11 ft. per shift being attainable by some miners, though 6 ft. is the average aimed at. The amount of ore broken down per day by each man is found to be between 1½ to 1¾ tons (the total number of miners being 30, and the weekly output from 260 to 315 tons of ore).

The broken ore is trucked along the drives to a storage hopper between No. 3 and the mill adits, and thence it is drawn as required for the supply of the battery.

The substitution of a well-thought-out system of open-cutting for that of stoping is now being considered in order that the ore of veins smaller than 20 in. in thickness—most of which is now lost—may be recovered, so greatly increasing the yield from each given block of ground. Mr. West is confident that at the same time the cost of winning the ore will be reduced to at most 2s. 6d. and possibly to 1s. 6d. per ton.

The extreme dryness of the vein materials is due to the workings being still above ground water level and to the detachment of the veins from the wall rocks. In only one place on the whole field (*i.e.*, Williamson's and Sorensen's shaft on the X-Rays claim) were the walls observed to be wet; but during certain meteorological conditions of low pressure a very slight seepage has been noticed in the deeper workings of the company. There have been some complaints from miners as to this extreme dryness and the dusty nature of the ore being prejudicial to their health, but the splendid ventilation of the company's workings leaves little if anything to be desired.

COSTS.

The total mining costs fell from 19s. 3½d. in February (a wet month) to 13s. 11d. in August last; but the rise in wages coming into force in the following month brought the figure for September to 15s. 3d. per ton. This last is thought to have been otherwise an average month and the following statement of details is interesting as the costs incurred in mining 1,082 tons of ore:—

	Costs per ton.	
	s. *d.*	*s.* *d.*
Explosives—		
Gelignite	0 7·8	
Fuse	0 1·3	
Detonators	0 0·5	
		0 9·6
Stores—		
Candles	0 1·0	
General	0 2·0	
		0 3·0
Timbering—		
Stulls	0 1·2	
Wages	0 9·4	
		0 10·6
Smithy—		
Blacksmith	0 0·4	
Charcoal and tool sharpening	0 11·5	
		0 11·9

	Costs per ton.			
	s.	*d.*	*s.*	*d.*
Mining—*				
Wages	8	10·7		
Nippering	0	4·8		
Mullocking	0	8·7		
Trucking	1	2·4		
			11	2·6
Management—				
Local Manager				
Underground Manager	1	1·5		
Office				
			1	1·5
Total			15	3·2

Tributing.

Tributes have been let to some extent both by private claim-holders and by the company. The usual terms are that 10 per cent. of the value of the wolfram won be paid in royalty, the wolfram concentrates being sold by the tributer to the highest bidder. The ore is hand treated by the tributers in all cases, and I was informed by tributers of experience that at the best this means nothing more than good wages for them—say, £4 per week—because of there being no bonanzas in the veins of Mount Carbine.

The system is falling into discredit because of the damage frequently done during the tribute, the tributers being naturally in a hurry to work out the richest ore, and seldom having time to think of the future of the mine. The Irvinebank Company has lately been giving only very short tributes, and in the near future is likely to refuse to let out any of its ground.

* Little or no development done. Driving usually returned as mining, because then breaking down ore. When driving in hard slate cost is understood to have been less than £2 per foot, though contractors are asking much more.

TREATMENT.

The production by primitive methods of treatment has been a negligible quantity since the Irvinebank Company erected its battery and concentrating plant, even though this, contrary to expectations, has not been thrown open for the reception of public stone. Record results are believed to have been attained at this mill, and it is anticipated that still further reductions in costs will eventuate when various additions and alterations have been effected.

Preliminary.

The prospector, like the company, usually brings all lode material to the surface, and there sorts it, poor or barren quartz being thrown over the tip, while any showing rich mineral is broken down to 3 in. size by means of a knapping hammer on an

PHOTO. 9.—PROSPECTOR'S TREATMENT PLANT, SHOWING SPRING DOLLY AND KILN, WITH PILE OF ORE READY TO BE FIRED.

iron plate or anvil (at the Ruby mine this "specimen" stone averages 20 per cent. wolfram), roasted on a kiln of firewood, then pulverised either by spring dolly or by hand, and jigged either by hand or in a box jig. The fines produced during the knapping are roughly hand-seived (½-in. mesh) to eliminate

the coarser barren quartz, sized by throwing onto a 16-mesh screen, and then hand-jigged in a tub, or else in a box jig (as at the Little Nell).

The hand jig consists simply of an ordinary circular sieve agitated by hand in a tub of water. It is stated that at the opening of the field the hand-jigging was done by the miner standing in the running stream, and the loss of wolfram in such circumstances must have been very heavy. The box jig has a tray, 18 in. by 2 ft. in area, suspended from the short arm of a

PHOTO. 10.—BOX-JIG AT LITTLE NELL.

lever and free to move up and down in a rectangular box nearly full of water. This is given a rapid succession of short sharp jerks, which causes the wolfram to sink to the wire bottom, while the gangue floats above it and is periodically skimmed off by the jig-man. The capacity of one of these jigs is nearly 1½ tons of fines per day.

Sluicing gives a product quite 1½ per cent. higher in grade than hand jigging, but water for sluicing is available during very few weeks in the year at Mount Carbine. That the loss by sluicing is ordinarily high may be inferred from the fact that

the Irvinebank Company in its sluicing campaign (undertaken prior to the erection of the battery with a view to determining the value of the ore), made an extraction of only 87 per cent. on the 2 per cent. ore under trial. In all 6,500 tons of ore was removed from the crops, chiefly on the Mount Carbine No. 1, but 77 per cent. of this was discarded after knapping. The remaining 1,500 tons was then sluiced for a yield of 110 tons of wolfram, which is equivalent to 7 1/3 per cent. in the material sluiced, but the tails still contained 1·1 per cent. of wolfram, and, as elsewhere described, these have since been retreated.

There is an idea prevalent among the miners that roasting destroys scheelite, and reduces the yield of wolfram. That there may be a complete loss in the case of the former mineral and a severe loss in that of the latter is true, and this is wholly due to disintegration at the temperature of the kiln and consequent *sliming* in water, after dollying. When an appreciable percentage of scheelite is known to accompany the wolfram, roasting must therefore be omitted to obviate loss. At the D.C.L. claim the fines as they come from the mine are jigged and yield scheelite; but the larger blocks have to be "kilned," and their scheelite is lost in the subsequent jigging.

Milling.

The Irvinebank Company is in the fortunate position of being able to dispense with all preliminary dressing of the ore, the whole of which as broken down is sent to the mill hoppers, for if any were picked out it would have to be knapped by hand and that would cost more than crushing by machine. In any case little of the ore as it comes from the mine is in large blocks, for the cohesiveness of the already friable quartz is further weakened by the disseminated felspar and wolfram, and blasting reduces it to small fragments, so that quite 40 per cent. passes through a ¾-in. screen.

The ore is tipped from the trucks at the mouth of the mill adit into a double V-shaped 20-ton hopper, originally provided with grizzlies let into the bottom, but these gave so much trouble by clogging that they have been dispensed with, and all the uncrushed ore now discharges from chutes onto a central platform, whence it is fed by hand into a 16-in. Hadfield cracker. The capacity of the machine, which requires 4-h.p., is 20 tons per hour; but the weekly capacity of the stampers being only 260 to 315 tons, it is run intermittently and during the day shift alone. The crushed stone falls on to a percussion launder, and is fed into a bucket elevator, which carries it to a 70-ton hopper

above the battery. From this hopper the ore is charged, by means of patent percussion chute-form feeders, into the mortar boxes.

The battery, comprising two units of 5 head of stampers and built by Walkers Limited, has a compound frame of steel

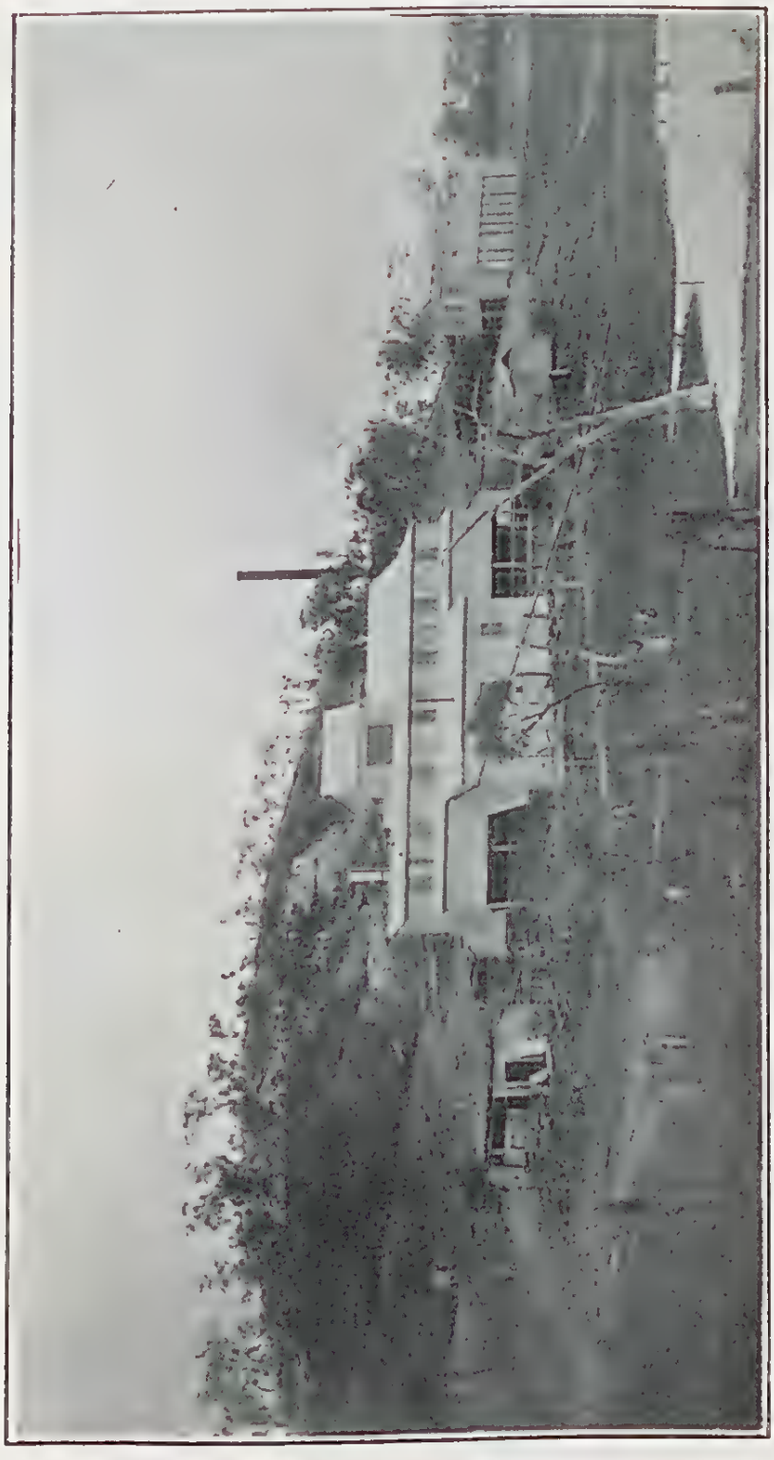


Photo. 11.—South-eastern End of Carbine Hill, and the Mill from below.

and timber, the mortar boxes having single discharge, provided with 8-mesh screen. The stampers, each of which weighs 1,200 lb., make 98 drops of 6½ in. per minute; and the duty of each stamp is 5 tons per day of 24 hours. Two further units of 5 head were

in course of erection at the end of the year, and for the filling of the new hopper it was proposed to install a horizontal conveyer from the bucket elevator. The management has hopes that this expansion will be followed by reduced costs per ton, as it is not anticipated that any increase in the present battery crew will be needed to attend to the 20 head.

PHOTO. 12.—THE IRVINEBANK COMPANY'S MILL, MOUNT CARBINE, FROM ABOVE.

For the crushing of 1,500 tons of fines, produced and sluiced by the company prior to the erection of the battery, a 5-ft. Huntington mill was put in temporarily, but, the whole of the fines having been put through at the rate of 80 tons per week (day shift only), the machine has now been again dismantled.

Concentrating.

The pulp from the two separate stamper units is not mixed, but feeds two separate plants, differing only in the design of the Card tables and each comprising a Card, Baby Krupp and Krupp table* with two Luhrig vanners, a Wheeler pan, upward current classifier, and a series of conical settlers.

The pulp from the battery screens gravitates into an upward current classifier, the underflow from which is run onto a Card table, producing a concentrate, seconds (that are recrushed in a Wheeler pan and pumped back to the classifier), and a tail

* Mill men may be interested in the speed at which the tables are run, and it may be mentioned that the improved Card receives 260, the Baby Krupp 360, and the Krupp 380 pulsations per minute.

that goes to waste. The overflow from the classifier passes into a 2-ft. settler, the coarse from which discharges on the Baby Krupp table, producing a concentrate (troughed), seconds (returned to the classifier), and tail. The overflow from the first settler is run into a second (2 ft. 6 in. diam.), the pulp from which feeds the large Krupp table (with products as in the case

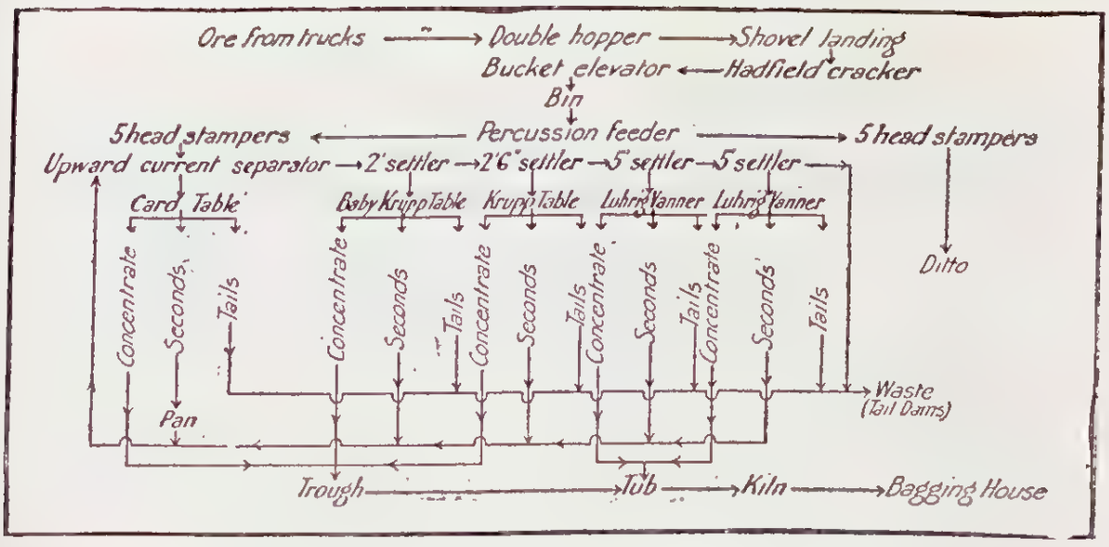


Fig. 14.—Flow-sheet, Irvinebank Company's Mill.

of the Baby). The overflow from the second settler is led to a third and a fourth (each 5 ft. in diam.), and the pulp from these feeds the first and second Luhrig vanners, which yield concentrates (tubbed), seconds (pumped back to the classifier), and tails run to waste. The waste water from the last conical settler is run through a number of settlers of various forms,* and then clarified with ashes from the boiler furnace prior to being used over again. The tails run to waste carry 0·2 per cent. wolfram (*fide* Mr. C. West), and the extraction is therefore 87 per cent. of the total content of the ore.

The troughs for cleaning the Krupp concentrate are of the usual pattern, about 10 ft. long and 18 in. in cross section, but the dressing tub has certain special features. It stands 4 ft. high, is 3 ft. across at the top, and is fitted with revolving blades for the agitation of the concentrate, the packing of which below any lighter gangue is ensured by a mechanical knocker actuated by a spring and cam worked off the shaft which causes the blades to revolve.

That part of the mill building occupied by concentrating apparatus is floored with concrete, in accordance with the latest

* Including a set of plunger jigs erected with the battery, but found quite unsuitable for such low-grade ore as that of Mount Carbine.

views on the subject of perfect cleanliness, allowing of hosing down as often as necessary without any loss of concentrate that may have splashed over.

The weekly production seldom varies much from 5 tons of concentrate, falling to 4 tons when poor ground is entered and rising to 9 tons in the exceptional case of several rich patches being entered at one time.

Early in the new year, when the 20 head of stamps are at work, the mill will have to treat double the quantity of pulp, and that it is capable of doing so has already been shown by half the plant taking the whole of the pulp from the 10 head now running. It is recognised that there will be increased liability to loss in the tailings, and that therefore extra attention will be required from the attendants; and it was at first proposed to instal two more Krupp tables.

COSTS.

The cost of crushing and concentrating is believed to be low, but figures are not available for publication.

Power Production.

The steam plant has been adapted, not designed, for the special work. The single acting engine, which came from the old Coolgarra mill, is large enough to drive 40 head of stampers, and therefore much too powerful for this 10-head battery and mill. Constant attention has to be given to the running of the tables, as the control of the engine is difficult, and a very slight variation in its speed suffices to greatly alter the number of pulsations given the tables per minute. Steam is produced in a multitubular wood-fired boiler.

Mill and office are fitted with electric light, current being generated by a Newton dynamo delivering 100 amperes at 105 volts.

A separate vertical boiler is provided for the horizontal double-acting Worthington pump that forces the water from the dam to the mill, the lift to the storage tanks above the intake being 100 ft., and distance of the mill from the dam being 16 chains.

The boilers are dependent on local timber (ironbark and teatree) for fuel, but the quality is inferior and the supplies are becoming increasingly difficult to maintain, as shown by the continually rising cost. In September last, cutting by contract cost 5s. 6d., and carting by the company cost 13s. 3d., a total of

18s. 9d. per cord. The mill boiler consumes about 100 cords a month, and that at the pumping station rather more than half that quantity.

It is not unlikely that before long the present plant, in view of its age and the difficulty of obtaining firewood, will be replaced by suction gas producers, and a further reduction in cost may then be looked for.

Drying.

Prior to bagging, the ore has to be dried, and for this a furnace of special design has been built. In plan it is circular, with an annular feeding space surrounding the central conical furnace chamber and flue. The concentrate is thrown on the cone, and sticks till dry, when it trickles down into receptacles on the bagging floor. The furnace chamber is 4 ft. in diameter and 8 ft. in height (*i.e.*, from floor to floor). The feed spaces rapidly contract below the tubbing floor, and special openings in the walls below allow escape of the steam that would otherwise find its way into the mill. The fuel consumption of the furnace is ½-cord of rejected firewood per week; whence we may assume that its efficiency is satisfactory, allowing that the fuel is waste and of the lowest calorific value; for the amount of concentrate to be dried is 5 tons per week, and the moisture content as fed into the drier may reach 6 per cent. by weight (the air space in the dry concentrate being about 30 per cent. of the total volume).

PRODUCTION.

A complete record of Mount Carbine production does not appear to have been kept, but the Warden's books* at Herberton give the monthly output for 1909 and 1910, with the following totals:—

Year.	Ore.	Concentrates.*	Value.
	Tons.	Tons.	
1909	..	$54\frac{17}{20}$	£4,987
1910	2,695	$179\frac{13}{20}$	£17,326

* As elsewhere stated, the tenor of the Mount Carbine concentrates is seldom below 70% and sometimes reaches 74% WO_3.

Subjoined is a summary of the Irvinebank Company's operations as recorded at the Mount Carbine office:—

Year.	Ore.	Yield.	Grade.	Sales.	Value.
	Tons.	Tons cwt. qr. lb.		Tons cwt. qr. lb	£ s. d.
1906 ..	..	..	..	..	97 7 7
1907 ..	..	..	..	17 18 2 16	2,726 3 11
1908 ..	..	..	..	36 11 1 21	1,816 2 8
1809 ..	..	..	..	1 16 0 11	119 1 2
1910 ..	$6,595\frac{5}{20}$	148 4 0 0 =	$2\frac{1}{4}$%	92 10 3 20	9,343 12 2
1911 ..	$1,174\frac{10}{20}$	17 18 2 0 =	$1\frac{1}{2}$%	196 6 3 13	18,631 9 11
1912 ..	16,976	260 7 3 16	$1\frac{1}{2}$%	260 7 3 16	24,191 10 10
1907-12*	..	..	..	60 17 3 4*	*5,780 13 3
Totals..	$24,745\frac{15}{20}$	426 10 1 16	$1\frac{3}{4}$%	666 9 2 17	£62,706 1 6

* Tributers to 1st November.

I have been unable to ascertain even approximately the production of the whole field, but the yield of the claims not now held by the company may have reached 300 tons (the sum of the partial estimates given below is 231 tons), and the grand total would therefore be probably not far short of 1,000 tons.

* Examined in 1911.

MARKET.

The market has hitherto been an extremely unstable one, but tungsten is now of such import to the metallurgist that the demand must gradually increase in firmness, and there need be no fear for the future of the wolfram mining industry on that score.

Buyers.

The Irvinebank Company, besides being the chief producer, is also in the market as a buyer, and formerly made its purchases through a private agent, who also handled the whole of the company's output on commission, but now the buying is done by the company's own officials. Three other large Australian ore-buying firms interested to a slight extent are Lohmann and Co., Dalgety and Co., and Lempriere and Co., each of which is represented by an agent on the field. The ruling price is periodically posted to these agents from the head office, and they are nominally open to buy at any time. The claimholders, however, have an idea that there is seldom much active competition between the firms, who seem to require supplies more or less in rotation, their requirements being easily gauged by the prices they offer.

The whole of the Irvinebank Company's ore is shipped to London, but ultimately, like that of the other buyers, finds its way to reduction works in Germany.

Quotations.

I have been credibly informed that, taking the Carbine claims as a whole, small parties cannot profitably work the reefs with wolfram averaging less than £100 per ton on the field. Such has unfortunately been the state of affairs for the past 18 months, and to it is to be ascribed in part the abandonment of so many of the old holdings.

The Irvinebank Company makes a periodical quotation at Cairns for the information of all its branches, and the price offered at Mount Carbine is £5 less than this, the allowance being made to cover commission, cost of transport, and risk of overestimating the tungstic acid content.*

Attached is a graph showing the fluctuations in the price of wolfram at Mount Carbine† during the five years 1908 to

* The actual allowance made for this risk is less than 1% of the value of the ore.

† This has been prepared fron figures supplied by Mr. A. Burton, of the Irvinebank Company, these including both the Company's own quotations and those of rival buyers; and the price plotted is that on which actual sales were effected.

1912, together with the contemporary quotations in London.* The depression of 1908 is clearly marked, as is also the boom of 1910, and the long period of medium prices closed by the upward tendency of the market towards the end of last year.

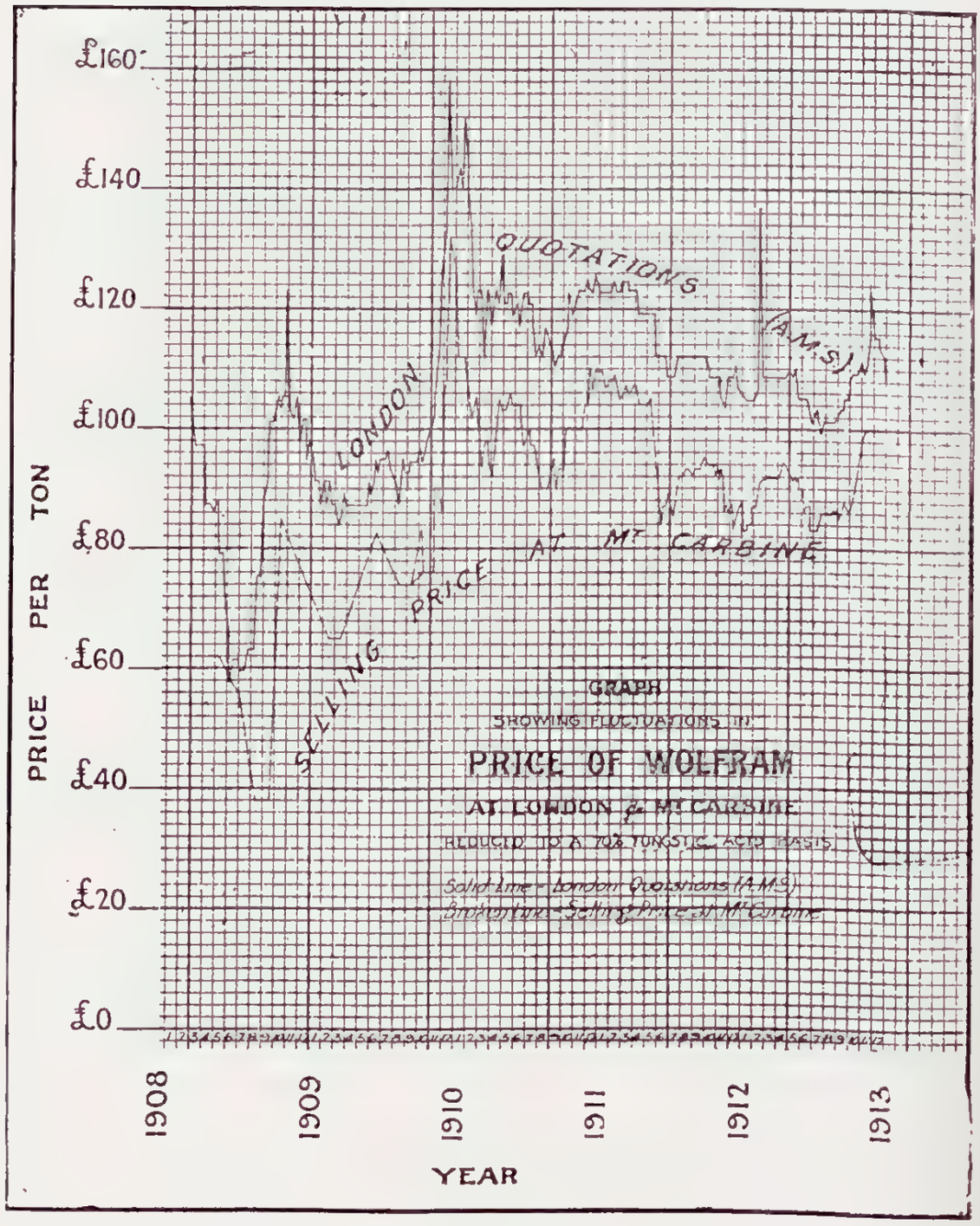


Fig. 15.

The similarity in the local and home curves is striking, and proves that the buyers must minimise the risk of a fall by keeping in closest touch with the European houses; and the £20 margin allowed on the London quotation does not seem excessive considering the instability of the demand and the distance of the mines from the centres of consumption.

* Compiled from weekly cabled quotations given in the "Australian Mining Standard."

REGISTER OF HOLDINGS.*

The Warden's books at Herberton are a blank concerning Mount Carbine for years prior to 1904, but during that and the following years, the state of the industry may be roughly gauged by the number of applications for claims and leases as tabulated hereunder.

——	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.
Claims	21	11	14	28	7	10	12	3
Leases	..	1	..	3	..	1	1	..

It is doubtful if in the earliest days any of the holdings were registered, and even now, unless the wolfram prospector discovers rich ground, he seldom takes the trouble to protect himself, as jumping is a most rare proceeding.

During 1912 there were 8 mining leases in force and 13 claims, besides which 4 unregistered holdings were being worked. Of the leases the Irvinebank Company holds all except the Mount Carbine No. 1, in which it has a controlling interest; and it also holds two of the claims (the Little Nell and the Harp).

* PLANS.—A 20 ch. plan of the mining lease and township allotment boundaries was compiled for my use by Mr. Crosswaite, of the Warden's Office at Herberton, and this served as the groundwork for my topographic sketch map of the hill. A contour plan of the extreme south-eastern end of the hill had already been prepared (on a scale of 5⅓ ch. to an inch) by Mr. O. H. Woodward, and his work has been incorporated also. A splendid series of underground plans has been drawn on a large scale by Mr. Woodward, and I was privileged to take tracings of reduced blue prints of these at the mine before beginning my work; and, in addition, Mr. Woodward himself supplied me with tracings of the Johnson and Syndicate lease workings on a scale of 20 and 40 ft. to an inch.

The plans accompanying this report are little more than diagrammatic of those prepared in the field, the publication of which complete would have entailed heavy expense in draughting and printing.

The following is the complete list of holdings in force or being worked:—

Leases.	Claims.	Unregistered.
Combination*	D.C.L.	Fitzgerald's
Dam Site	Edith	Rhodes's
Johnson	Eye Opener	Simpson and Beadles's
Mount Carbine No. 1	Harp	
Polygonic	Iolanthe	
Pump Site	Little Nell	
Rolfe	Lone Hand	
Tungsten	Lucky Hit	
	R.S.B.	
	Ruby United	
	Struggle	
	Triangle	
	X Rays	

* Machine area.

The descriptions below are headed by the name of the holding followed by its registered number, M.L. standing for mineral lease, M.C. for mining claim, and A.C. for alluvial claim. The figure at the beginning of each description is the year in which the holding was registered.

Anderson (M.L. 7244).

1904—Included in Johnson, at southern end.

Australitz (M.C. 7411).

1905—Between Wayback and Iolanthe. Included in Combination.

Baird's Bluff (M.C. 7208).

1904—The first claim pegged out and registered=Mount Carbine No. 1, *q.v.*

Battler (A.C. 9518).

1909—South of Mona on Bock's Gully. Alluvial Ground.

Battler (A.C. 9744).

1910—"West of Harp" on Bock's Gully. Now held by Grogan.

A face from 3 to 6 ft. high is now being carried back from the eastern side of the gully, but as far as known the work is not highly profitable.

Bismarck (M.C. 8388).

1906—Diamond.

Black Bird (M.C. 8693).

1907—North-west of Daisy. Abandoned.

There are a number of shallow holes and trenches on the hill-side between the Daisy and Jack Watson on leaders trending west-by-north; but they are too small to warrant further work. An unusual feature is a cross leader striking north-east that has also been potholed.

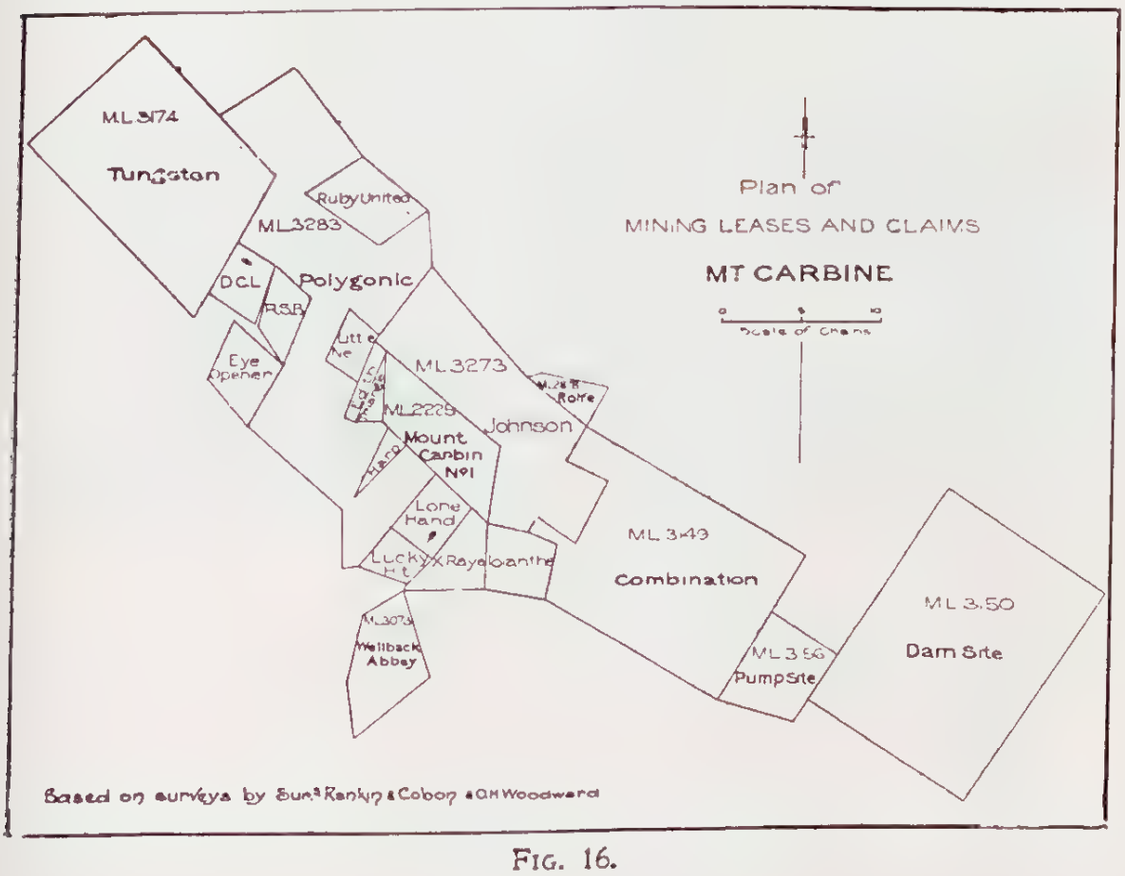


FIG. 16.

Borcham's Iron Blow.

On a spur overlooking the western branch of Holmes' Creek, about ¾-mile north of Sundet's gossan crop—otherwise located 2 miles north-north-west of Carbine Hill.

It has not been pegged out, but is worthy of some attention from the prospector.

This is a silicified crop of quartz and gossan-veined schist, much stained by iron and manganese oxides, and it may possibly be the cap of a low-grade siliceous formation. It has a length of 4 chains and a width of 1½ chains. Its situation is ideal for testing by adits, one of which might be put in at the lower edge of the crop 40 ft. below the crest, and others of moderate length could start from the gully to the north-west to give several hundred feet of backs.

Bonser (A.C. 8360).

1906—North of Rolfe. Abandoned.

A series of short lenticular and branching leaders have been trenched and potholed, but the workings were filled in as the face advanced and the one shaft has caved in. One of the veins is 6 in., another 7 in., and a third (that on which the shaft was sunk) up to 15 in. thick, but they are irregular in their occurrence and presumably could not be profitably followed further.

Caledonia (M.C. 8123).

1906—Jack Watson?

Caledonia (M.C. 9136).

1908—R.S.B.

Carbine Block (M.C. 8372).

1906—Included in Johnson.

Little work has been done on this part of the Johnson, but on it there are several large mullock dumps that will either wholly or in part eventually be put through the mill for their wolfram contents.

Catherine (A.C. 8834).

1907—Between Polygonic, Lucky Hit, and Wellbeck Abbey. Bought by the Irvinebank Company, but subsequently abandoned.

No reefs are known to crop on this ground, but a good deal of surface work has been done, and at the present time two men are working unregistered floater claims on it. Fitzgerald in the northern part is getting fair nuggety wolfram, and Rhodes in the eastern part has been winning wolfram yielding him £2 10s. per week wages. The face of the latter's paddock is 10 ft. wide, and his advance has been 30 ft., while the average depth has averaged 4 ft. Thus the ground carries slightly less than ½ per cent. of wolfram.

Chance (M.C. 8418).

1907—North-west of True Blue. Abandoned.

This claim seems to have been at the north-western end of the True Blue line, where there are numerous caved cuts and shafts on leaders believed to be small.

Combination (M.L. 3149).

1909—Mill site and tailings area at the south-eastern end of the hill. Held by the Irvinebank Company.

The lodes coming down the hill from the north-west have mostly petered out before reaching this ground, but several veins

6 in. to 12 in. in thickness have been trenched in the northern part of the lease (on the continuation of the Nil line) and a few small leaders carrying wolfram have been exposed in excavating for the foundations of the mill.

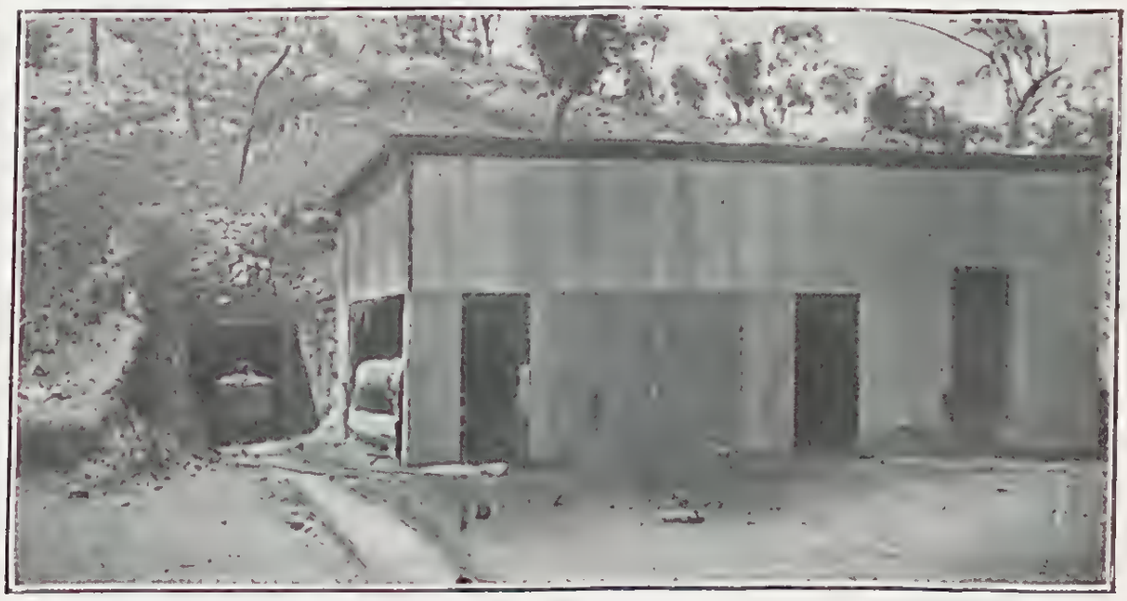


Photo. 13.—Entrance to Mill Adit, Combination.

Daisy (M.C. 8176).

1906—See Daisy United.

Daisy United (M.C. 8328).

1906—North-western end of hill. Abandoned.

It is known that the workings on the ridge crest near the summit of Carbine Hill were within the claim, but the position of the claim boundaries cannot now be located.

These workings include two 30 ft. shafts, three adits (one 90 ft. long and the others each 30 ft. long) and a number of trenches. (*See* Fig. 17.)

The vein or vein systems, for they are made up of overlapping lenses, are small (4 to 8 inches in thickness), but one series has been followed for a distance of 6 chains. Some stoping has been done between the adits and the surface and one of the stops is 53 ft. long. The strike of the veins is with exceptions west-north-west, but that of the bedding of the augen-slate country is north-north-west.

To the south-east the veins become more numerous, but they are still mostly small, and no continuous developmental work has been expended on them.

The fossickers were handicapped by the toughness of the lode material, which is due to felspar being absent or present

in only very small proportions. The Daisy United wolfram is somewhat characteristic, being feathery and finely acicular, and besides shows a tendency to segregation near the walls.

Dam Site (M.L. 3150).

1911—Now held by the Irvinebank Company.

This is below the mill, which derives its water supply from a dam thrown across Manganese Creek and from an adjacent well. The building of the dam was a matter of great expense, owing to the depth of alluvial along the eastern side of the creek necessitating a puddle wall 140 ft. long and 30 ft. deep.

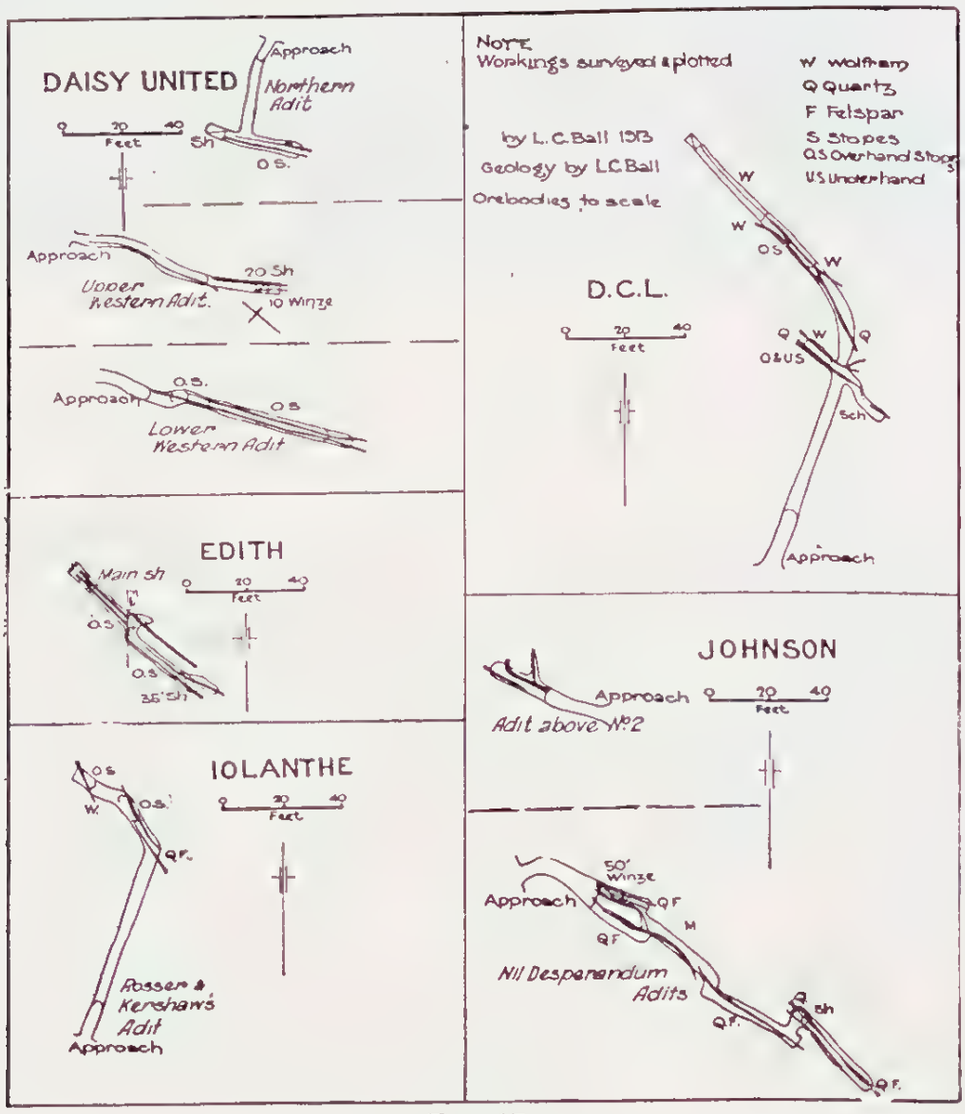


FIG. 17.

Daniel (M.C. 9846).

1911—¼-mile north-north-east of battery, near Scheelite Gully. Abandoned.

A little surfacing has been done at intervals on a narrow floater stream coming out from Scheelite Gully—the ground was probably very poor.

D.C.L. (M.C. 8296).

1906—This lies between the Tungsten, Polygonic, R.S.B., and Eye Opener. It is now held by Brown.

The Bluff is the chief series of reefs worked here, but there are others on either side of it. One of the Bluff veins has been removed by opencut almost from side to side of the claim, and a

Photo. 14.—Adits on D.C.L.

good deal of work has been done on another of the same series. Up the hillside there are a few trenches, and down the gully below the main line there are two flooded shafts said to be 30 ft. deep.

The main workings are reached by two adits, the lower one

108 ft. from the approach to the stope,* where a system of intersecting veins (3 to 12 in. thick) has been exploited by a stope 30 ft. in length and now open to the surface. At 70 ft. from the mouth of the adit* a system trending north-west was driven on to right and left and beyond that small cross veins were followed to the main line, which also strikes north-west. (*See* Fig. 17.)

Brown is now working on the outer north-west drive, and in the face there are showing three veins respectively 3, 6, and 9 in. thick. The wolfram content is not high, but there is some scheelite and the yield affords wages. When much rich ore shows and market quotations are high, wages men are put on; but just now the claim holder is alone, the fact that the ground stands well and requires no timber having hitherto been in his favour. The workings are, nevertheless, becoming too extensive for the veins to be profitably exploited by one man.

The occurrence of the wolfram is bunchy, and Mr. Brown has noticed that it is to some extent dependent on intersecting cross leaders. A patch of cupriferous gossan on the surface led to this ground being pegged out, but in the lower workings there are only slight stains of malachite and azurite, the sulphides not yet having been reached.

Mr. Brown informs me that during the last six years he has produced a total of 16 tons of wolfram (and scheelite) and during 1912 his production was 1 15/20 ton of the concentrate.

Dead Dog (M.C. 9681).

1910—South of X Rays. Abandoned.

The Dead Dog is believed to be the extreme end of the worked floater ground below (to the south of) the Iolanthe.

Dead Finish (M.C. 7264).

1904—Included in the Dead Finish Amalgamated.

Hobein, the original holder, is said to have cleared £1,100 by surfacing here.

Dead Finish Amalgamated (M.C. 8517).

1907—Between the Harp and Lone Hand. Included in Polygonic.

Much surfacing has been done in the eastern part, and some work has been carried out in the Iolanthe zone in the northern part, this latter including an opencut (mullocked up), a flooded

* In the attached plan [Fig. 17) the approach has been wrongly superimposed on the adit, thereby foreshortening it.

shaft, and an adit that reached the lode a few feet below the old workings. There is 15 to 18 in. of quartz and felspar in the drive at the end of the adit, but it seems to be pinching out towards the north-north-west.

The holding is chiefly of value as giving access to the Mount Carbine No. 1 by No. 3 adit. Part of No. 1 adit dump and the whole of No. 3 adit dump are on this ground.

The Company during 1910 produced 7/20 ton wolfram, valued at £37.

Dead Finish Extended (A.C. 8389).

1906—Included in Dead Finish Amalgamated.

Diamond (M.C. 9297).

1908—Included in Gems United.

At least two veins of the Ruby zone have been exploited here, but they were lost in the broken country on the north-western side of the lease; and two shafts sunk, one of them 40 ft., in search of the reef failed to relocate it. The miners spoke of faulting, but of this there is no certain indication, and it would seem that the main lodes have simply petered out. To the north-west of the Diamond only small and discontinuous leaders have been found on the trend of the Ruby line. The country is much jointed and is so open that the miners consider it "shattered."

Dolly Varden (M.C. 7268).

1904—Included in Dead Finish.

Dolly Varden 1*N* (M.C. 7433).

1905—Included in Dead Finish.

Dreadnought No. 1 (M.C. 9508).

1909—East of Carbine Hill. Abandoned.

The extent of the claim is unknown but it is thought to have been confined between Scheelite and Fitzgerald's Gullies, on a high northern shoulder of Carbine Hill. The Iron Duke zone, on which it is, comprises at least half a dozen separate and parallel veins, but none of them has been followed far, owing to their lenticular form.

A shaft in the top of the knob has caved in, but the ore at grass shows the vein to have been up to 2 ft. in thickness, and to have consisted of the quartz with a peculiar bluish tinge. The vein is traceable by shoads to the south-east, and, in one

place, where it bulges to 18 in. in thickness, a cut has been opened on it; but work was not continued because the vein pinched below.

Easter Monday (M.C. 7476).

1905—Included in Wayback.

Edith (M.C. 7237).

1904—Surrounded by Polygonic, Johnson, and Triangle. Now held by Petersen and party.

At the northern end of the claim, which is a very narrow one, the Nell zone is being worked, and in the central part some remunerative open cast work has to be done on veins of the Bluff zone.

PHOTO. 15.—EDITH, TRIANGLE, POLYGONIC, HARP, ETC.
VIEWED FROM NORTH-WEST.

Two shafts have been sunk 35 ft. on the Nell zone; an old one near the eastern boundary (mullocked up by tributers to within 20 ft. of the surface) and the main shaft on the western boundary, within 12 ft. of the Nell shaft. The two shafts are 50 ft. apart and they are connected by a drive. (*See* Fig. 17.) The workings show two parallel veins, one 10 in. and the other 15 in. thick (connected at the shaft by a 5 in. cross leader) and a third vein, 2 to 15 in. thick, has been broken into midway between the shafts. The mine was let on tribute last year, and

the owners have not in the last two months quite cleaned it up for stoping. The concentrate contains minute traces of molybdenite, and splashes of chalcopyrite are occasionally exposed in the faces.

The claim holders reckon that a total of 30 tons of wolfram has been won from the claim, half of it during the last three years.

Eye Opener (A.C. 9730).

1910—South-west of R.S.B. Now held by Owens.

No reefing has been done on this claim (the leaders in the northern part being barren) and but an insignificant amount of surface work, this being along gullies running down from the R.S.B. and the Polygonic. Preparations are being made, however, by the holder to do some sluicing during the next wet season.

Felsite Knob.

19— —Name of claim unknown, probably unregistered. About a mile and a-half east-by-north from the mill.

In the schists on the south-western side of a large felsite dyke a few quartz leaders have been found, one of which crossed a little wolfram, and this has been trenched in one place near the summit. Other small and discontinuous leaders in less altered slate country further down the hill to the south have been potholed, and one of them was rich in wolfram arranged at right angles to the confining walls.

Flat.

19— —Name of claim is unknown, probably unregistered.

On the low country near Manganese Creek, ½-mile north-east of the mill a little surface work has been done.

The country here is a decomposed porphyritic biotite granite but silicified slate crops nearby (to the north). There are a number of parallel reefs running north-westwards and in size up to 4 ft. thick. They consist of quartz with very little wolfram. The amount of work done is negligible.

Another group of wolfram-bearing quartz veins lies ¾-mile to the north-by-east of the mill in slate country. There is only a trace of wolfram showing and no work has been done on them.

Floater (A.C. 8792).

1907—Locality unspecified—probably Bock's Gully.

Flying Pig.

19— —South of Wolfram Crown?

Gems United (M.C. 9356).

1909—Comprises Pearl and Diamond. Included in Polygonic.

The Ruby United zones run west-north-westwards across this ground; and a good deal of open-cutting and trenching has been done thereon, besides the sinking of several shafts, two of which are 54 ft. deep, a third 43 ft., and a fourth 40 ft.

The company in 1911 produced 16/20 tons wolfram, valued at £78.

Gully (M.C. 7263).

1904—Bock's Gully, below Polygonic. Abandoned.
Floater ground.

Harp (M.L. 8068).

1906—Surrounded by Polygonic and Mount Carbine No. 1. Lately purchased from Rolls' by the Irvinebank Company.

The five old shafts on this ground, all of them flooded, are on the Iolanthe zone. One of the shafts is said to be 50 ft. deep, and a good deal of stoping was done, but the surface has now caved in above it.

Havelock (M.C. 8701).

1907—Included in Pick and Shovel, q.v.

Hit or Miss (M.C. 7243).

1904—Included in Polygonic.

A few shallow filled-in trenches, on the south side of the Little Nell, have been mullocked up, but were probably on small veins.

Hit or Miss (M.C. 8802).

1907—Included in Diamond.

Hit or Miss (M.C. 8865).

1907—South of "Last Chance." Abandoned.

Hopeful (M.C. 8935).

1907—North of Ida. Included in Tungsten.

The leaders here are small and irregular and little work has been done.

Hunter (M.C. 8441).

1907—North-west of Keatings. Abandoned.

Several shallow shafts were sunk on the True Blue zone here, but they have caved in. Simpson and Beadle have lately made an attempt to get into one of the old shafts by driving a short adit.

Huntress (M.C. 8905).

1907—Adjoining Hunter on north-west. Abandoned.

Shallow cuts and shafts were opened on the True Blue zone here, but the reef seems to fray out to the north-west.

Hurry Up (M.C. 7262).

1904—¼-mile south of Keatings. Abandoned.

A shallow trench and a caved cut were opened on lenticular leaders here, but nothing can now be seen of the veins.

Ida (M.C. 8377).

1906—Included in Tungsten. Believed to be the same as Mon Repos.

Iolanthe (M.C. 7410).

1905—South of Mount Carbine No. 1 and Johnson. Included in Iolanthe Extended. Commonly known as Klausen's.

Iolanthe Extended (M.C. 9485).

1909—South of Mount Carbine No. 1 and Johnson. Includes Iolanthe. Now held by Kershaw.

Two of the largest opencuts on the hill are in the north-eastern part of this claim. They are more or less mullocked up, but one end shows the following section:—

3 in.	6 ft.	9 in.	8 ft.	5 in.	18 in.	3 in.	8 ft.	7 in.
Quartz.	Country.	Quartz and Felspar.	Country.	Quartz.	Country.	Quartz.	Country.	Quartz and Felspar.

It is presumed that the veins bulged in the cut, but they must have pinched again, for at the opposite end there are only four leaders showing. These are on the Bluff zone.

A deep cut runs from the north-western corner to the centre of the claim on the Iolanthe zone, which is parallel to and about a chain from the Bluff. This is not now being worked and is caving in, but in different parts there is exposed 14 in. to 16 in. width of quartz and felspar.

The reef was intersected 30 ft. below the surface by an adit 70 ft. long, a drive was opened north-westwards along it, and some stoping was effected between cut and drive; but the vein is not likely to have been very rich as 12 in. quartz and felspar has been left standing in the face (this would otherwise have been broken into). The vein is slightly faulted in two places, and that may have helped to discourage the claimholder. (*See* Fig. 17.)

Kershaw's shaft, which is to be sunk to a depth of 50 ft., had reached 20 ft. below the surface in October last. It is on a 12-in. vein running slightly obliquely to that last mentioned but within 20 ft. of it. It is vertical on the average, but very undulatory besides jumping and curving along every break or head or joint. There is usually a patch of wolfram where these sudden changes take place and such a one is that at the 20-ft. level, where wolfram is showing on a bulge in the reef.

In lieu of any record, the claimholder estimated for me the production of the Iolanthe, the total being 30 tons. This, however, is acknowledged to be little better than a guess.

Iron Duke (M.C. 9004).

1907—Included in Dreadnought No. 1. Abandoned.

Ivy (M.C. 8551).

1907—Included in Huntress. Abandoned.

Jack Watson (M.C. 8799).

1907—West of Daisy United. Abandoned.

A superimposed opencut and adit, the latter 45 ft. in length, expose little except at the inner ends, where the quartz leader is 2 in. and 3 in. thick. Mr. Simpson tells me that wolfram shoot was 20 ft. long and that 1½ ton of wolfram was got here.

Johnson (M.C. 7240).

1904—Included in Johnson lease.

On the Johnson line there are a great number of interlacing trenches, the majority shallow and most of them filled in, but some are 20 ft. and exceptionally 30 ft. deep, and many of them connect with the stopes beolw. In very few cases are the trenches or cuts more than 6 ft. wide, each leader having been separately followed, even when only 3 or 4 ft. distant from a neighbour. The veins are up to 4 ft. 6 in. thick, and the work done is indicative of a large production.

On the Bobby Dazzler zone one 6-ton lump of wolfram, the largest yet found on the field, was got near the surface; but the vein proved somewhat disappointing where opened below by a drive from No. 2 adit, as the 18 in. of quartz pinched out within 30 ft. of the grass roots. Further work here should locate an overlap. (*See* Fig. 20.)

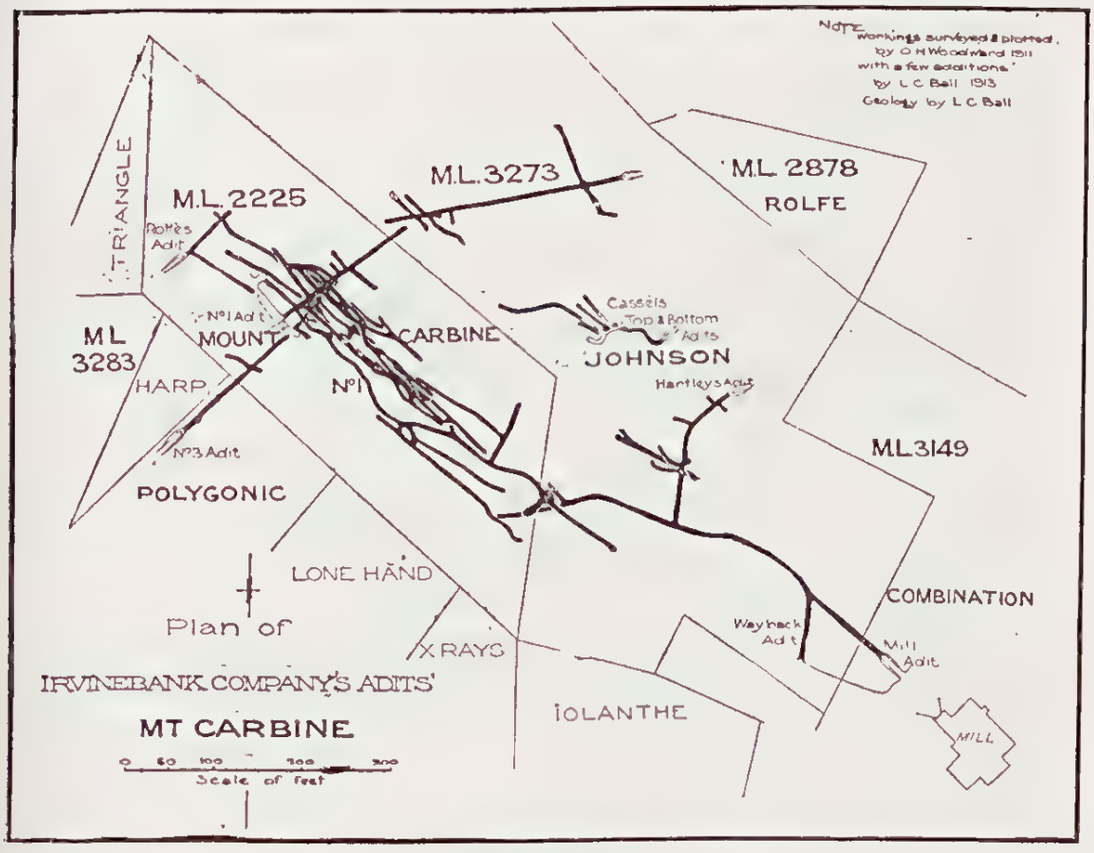


FIG. 18.

The ground has been entered by two adits—No. 2 and Asmus and Fry's—and there is one shaft 36 ft. deep, the last inaccessible. No. 2 adit is nearly 300 ft. long and gives about 50 ft.

of backs. It first intersects the Bobby Dazzler zone, of which one vein, followed 40 ft. south-east and north-west, is from 4 to 18 in. thick. Numerous other leaders were then passed through and 80 ft. back from the face the Johnson zone was entered. The veins of this group are as numerous and erratic in their trend as on the surface, but below ground are of less thickness than above —one, followed for over 100 ft. to the south-east, showing in some places only 3 or 4 in. of quartz and felspar though mostly between 18 in. and 2 ft., and in one place 3 ft. 6 in. wide. (*See* Fig. 20.)

Mr. Johnson informs me that his production from this claim during two years was between 8 and 9 tons of wolfram.

Johnson (M.L. 3273).

1911—Includes a number of claims (Wolfram Crown, Nil Desperandum, Johnson, Johnson and Williams, and Wayback) purchased by the Irvinebank Company.

At least six of the vein zones have been worked on this lease, these including the Natives, Bobby Dazzler, Nil, Johnson, Wayback, and Bluff.

The most extensive of the workings are those on the Johnson zone, the opencuts and trenches extending over a distance of 13 chains. Most of the veins have been separately trenched, but on Cassel's tribute a number were taken out by opencut. As now exposed the veins are mostly of small size, 6 in. to 18 in., but exceptionally they are 4 ft. 6 in. in thickness. They are characterised by the presence of much felspar, which, as elsewhere noticed, is looked on as favourable for the occurrence of wolfram. Some underground work has been done on the Johnson veins, which have been tapped by No. 2, Cassel's and Hartley's adits; but they do not, as a rule, exceed 18 in. in thickness in No. 2 adit, though there is one bunch of 3 ft. 6 in. In Hartley's workings they are still smaller, but in Cassell's stopes the reef has a width of more than 2 ft. over long stretches. (*See* Figs. 20 and 21.)

The Bobby Dazzler was also driven on from No. 2 adit, but was smaller than on the surface.

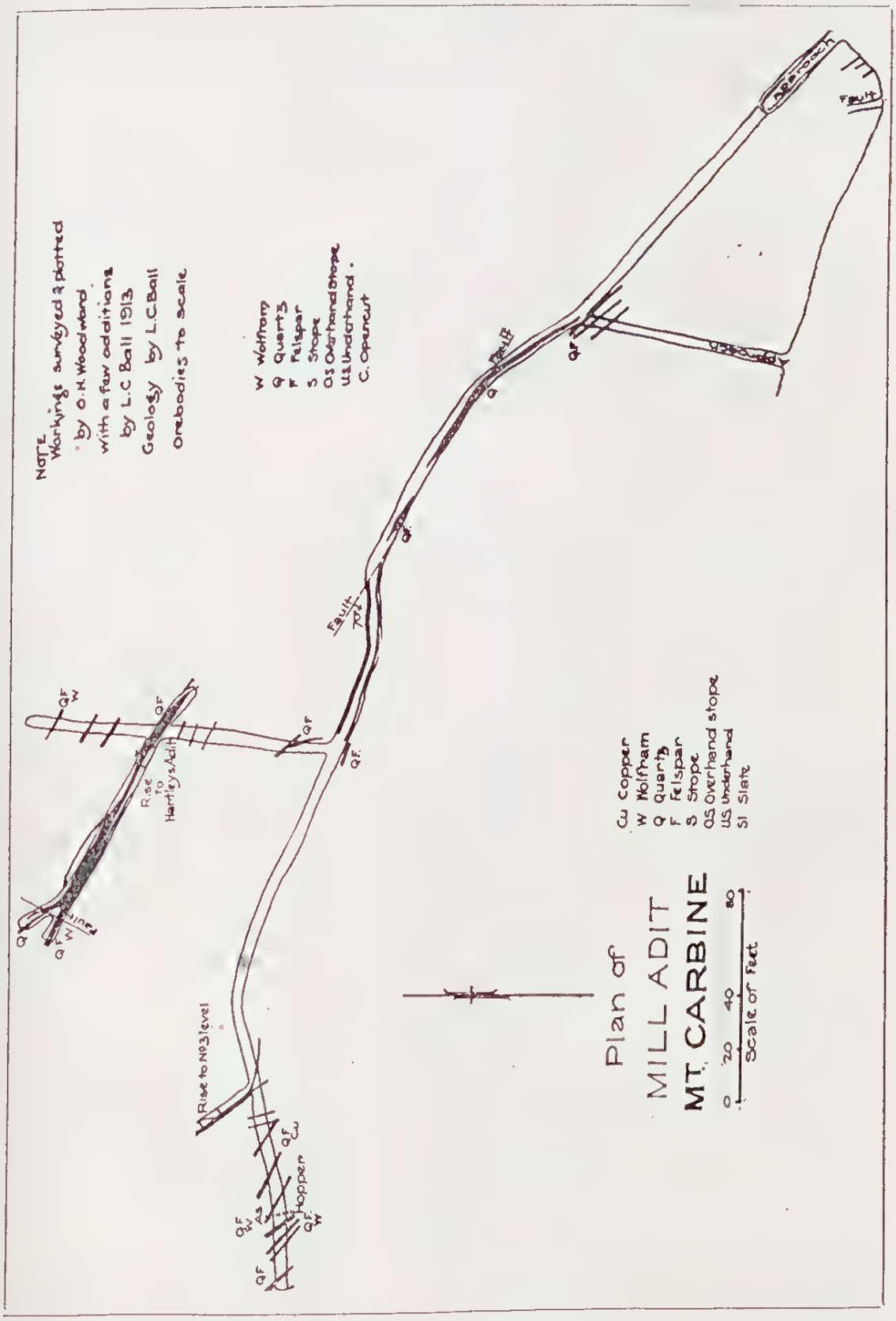


FIG. 19.

The Wayback zone has been deeply opencut and besides has been reached by Hartley's adit and by a crosscut from the mill adit. At this latter level it is proposed to follow the veins north-westwards into the hill and a drive has already been opened for 90 ft. from the crosscut, the reef ranging from 2 ft. to 4 ft. 6 in. in thickness. (*See* Figs. 18 and 20.)

No. 2 adit, in 290 ft., intersects 27 veins of total thickness 17½ ft., including 5 ft. in veins over 18 in. Hartley's adit, in 140 ft., proves a total of 11 ft., two veins being 18 in. in width. The mill adit, in a distance of 220 ft., proves 18 ft. width, of which the veins over 18 in. wide total 10½ ft. The mill adit and Hartley's give a section (not completed) in the southern part of the Johnson, the total exposure being 23 ft., with 12 ft. in veins over 18 in.

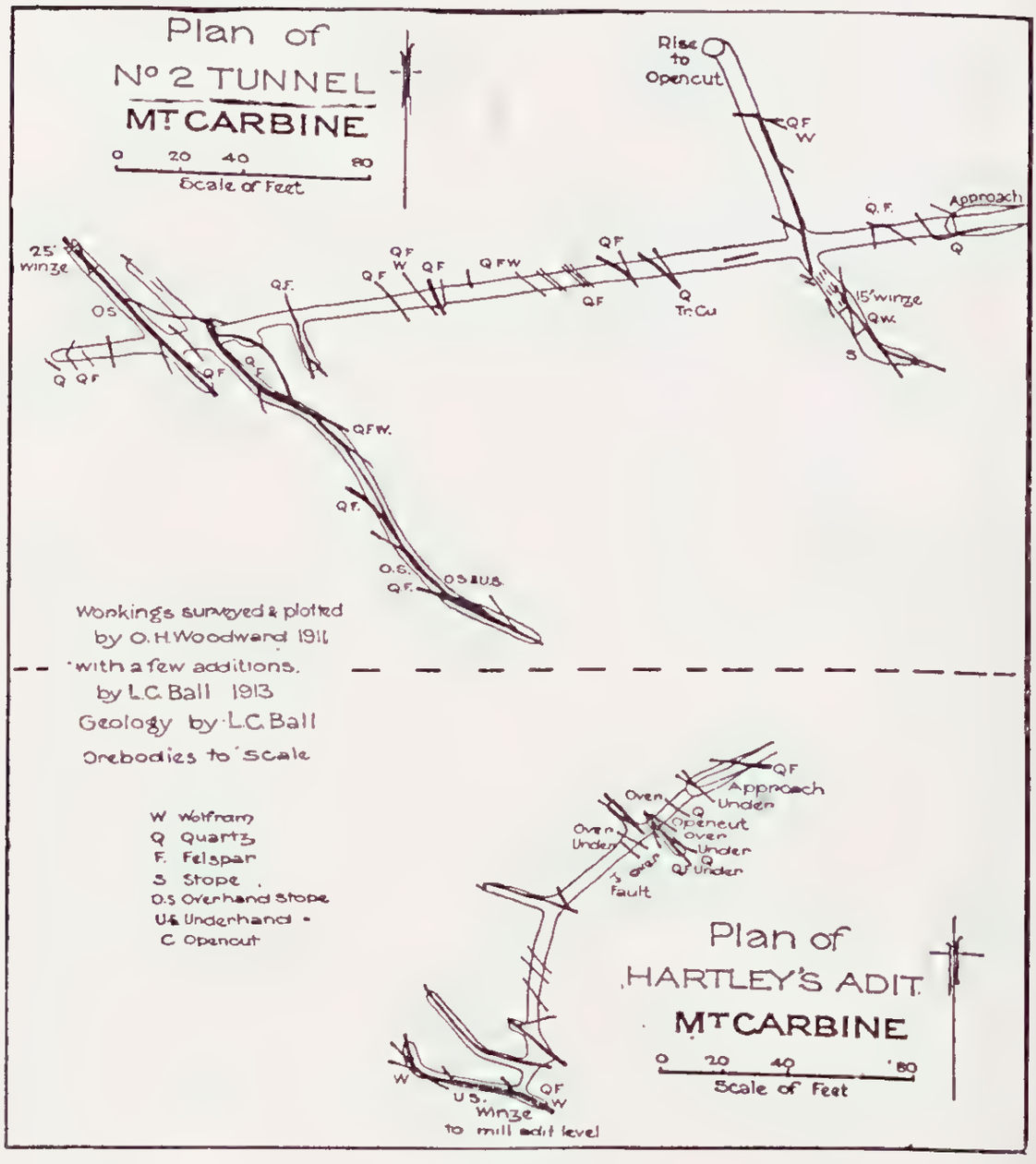


FIG. 20.

A necessarily rough estimate of the amount of "probable ore" on the Johnson lease above the adit level may be made from the data given on my original plan of the surface workings. As exposed on the surface the total width of veins over 12 in. in thickness is 22 ft. (12 ft. on the Bluff and Wayback, 7 ft. on the Johnson, and 3 ft. on the Dazzler; and the respective lengths of crop being 3½, 8, and 4 chains, with 110, 150, and 150 ft.,

the respective elevations above the adit level). This gives a grand total of 60,000 tons without any deduction, for, in omitting all veins under 12 in., of which there are a large number (any of which may become workable in a few feet), sufficient allowance has been made for possible thinning of the veins.

The Company and its tributers between November, 1907, and the end of 1912, produced £5,868 worth of wolfram, the amount being 61 8/20 tons; and the grade of the stone crushed during 1912 was 1½ per cent. The Company at the end of 1912 had mined and crushed 690 10/20 tons of ore from this claim for a yield of 11 6/20 tons wolfram, but the total quantity of wolfram from all sources sold since 1906 amounted to 74 9/20 tons, of a value of £7,166.

Johnson and Williams (M.C. 7241).

1904—Included in Johnson and Williams (M.C. 7611).

Johnson and Williams (M.C. 7611).

1905—Included in Johnson (M.L. 3273).

Most of Cassel's workings and the whole of Hartley's are included in this ground, as well as a great part of the mill adit with No. 1 crosscut and Nos. 1 and 2 drives.

Cassel's workings are on the Johnson zone, as are some of Hartley's, the remainder being on the Wayback and Bluff. The surface workings on both the Johnson and Wayback are extensive, there being large opencuts and numerous trenches.

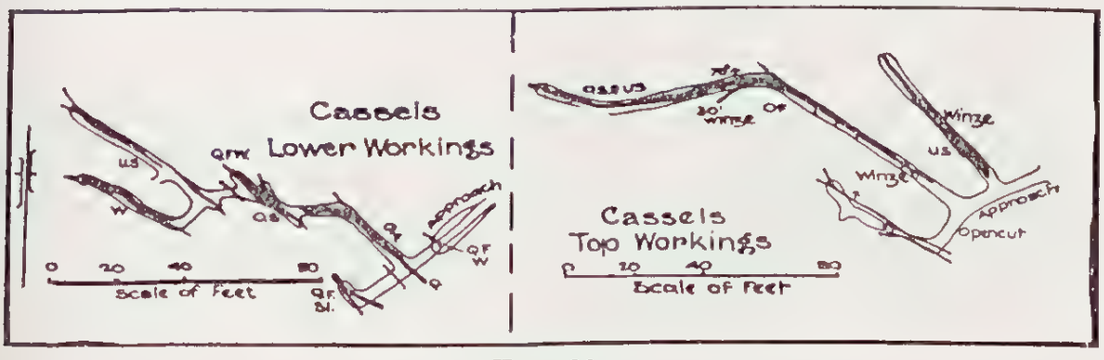


Fig. 21.

Five separate veins have been driven on and stoped from Cassel's adits, thicknesses of 2 ft. 6 in. to 4 ft. 6 in. being not uncommon here. The veins, where cut by Hartley's adit, are much smaller, and little work has been done on them thereabouts below ground.

A Wayback vein has been underhand stoped near the end of Hartley's adit, and connection has been made with the No. 2 N.W. drive from No. 1 crosscut off the mill adit, in which

drive there is up to 4 ft. 6 in. width of pegmatite. The vein is nevertheless very irregular, frequently petering out and branching off; but, as new overlaps come in, the drive is continuously on reef matter. Cross faulting or jointing is also a feature, the reefs showing no consistency of behaviour, some cutting off sharp, while others cross the joints without effect. (*See* Figs. 19 and 20.)

PHOTO. 16.—CASSEL'S TRIBUTE DUMPS, JOHNSON.
BAKER'S BLUE MOUNTAIN, MOUNT HOLMES, AND LITTLE ALTO IN DISTANCE (TO THE SOUTH-BY-EAST).

The Bluff veins thus far exposed in the end of the mill adit are not particularly encouraging though somewhat more propitious in the No. 3 above. The country here is more schistose and crenulated, the veins are more frequently frozen to the walls, and inclusions of country rock are quite unusually abundant. All this is indicative of some change having taken place in the character of the ore-bearing solutions and the conditions of deposition. We are here, however, at the south-eastern end of the Bluff zone, and improvement is to be expected as the drives are pushed out to the north-west. (See Fig. 19.)

Johnsons' output for this claim was 5 tons of wolfram.

John Watson (M.C. 8890).

1907—Jack Watson?

Joke (M.C. 8986).

1907—South-west of Polygonic? Bock's Gully.

Joseph (M.L. 2980).

1907—Included Bonser, Moonstone Natives, and Try Again. North-east of the Johnson and between the Rolfe and Scheelite Gully. Taken up by the Irvinebank Company but abandoned.

PHOTO. 17.—CARBINE HILL, FROM EAST-NORTH-EAST. WITH WORKINGS ON JOHNSON, JOSEPH, ETC.

Three zones (the Iron Duke, Bonser, and Natives) run north-westward across this ground, each comprising numerous separate irregular veins, usually of small size and somewhat erratic in their individual trend, though there is a general rude parallelism. The only work of any extent was done on the Moonstone Natives in the boundary cut that comes from the Johnson.

The stone from this side of the hill is rich in felspar, and besides wolfram carries much scheelite and some tinstone.

Jubilee (M.C. 9713).

1910—Adjoining Dreadnought. North-western end.

Two veins have been opened by cuts and on one of them a shaft was sunk 10 ft. The veins are small (from 3 to 9 in. thick) and have not yet proved to be persistent.

Just-in-Time (M.C. 8561).

1907—Included in Tungsten.

Sutherland's shaft was sunk 20 ft. in a gully near the centre of the Just-in-Time. This is probably on one of the Ruby leaders.

Just-in-Time (M.C. 8642).

1907—North-western end, adjoining the True Blue. Abandoned.

Sundet's adit was put in to test the south-eastern extension of the True Blue zone. The adit has caved and there is little on the surface to give encouragement to further work. Sundet's output was but a few hundredweight of wolfram for six months' work.

Just-in-Time (M.C. 9745).

1910—Included in Tungsten.

Beadle's workings, in the western part of the Tungsten, are on the Ruby zone. The eastern or gully workings comprise several old cuts on small (6 in.) leaders and are said to have yielded 7½ tons wolfram. The western shafts, of which four have been sunk on the underlie, are connected by an adit now caved. The leader is a cross one and only 6 in. thick.

Just-in-Time (M.C. 9289).

1908—Wayback.

Keatings (M.C. 8357).

1906—North-western end. Abandoned and later taken up as True Blue.

The True Blue vein here worked runs north-westwards underlying 70 degrees to north-east. Several opencuts and an old shaft sunk by Keating expose a vein 9 to 12 in. in thickness. The bottom workings have been rendered accessible by two adits, one of which was put in by Simpson after the ground had been abandoned by Keating. (See under True Blue.)

Keating's yield is estimated at between 3 and 4 tons of wolfram.

Last Call (M.C. 9731).

1910—South of McManis cut. Abandoned.

Several old caved trenches and cuts at the south-eastern end of the Daisy United zone expose three parallel leaders not more than 3 in. thick.

Last Call (M.C. 8282).

1906—Included in Combination.

The extreme south-eastern end of the Nil zone of leaders crops herein, and a few trenches have exposed veins 6 in. to 12 in. thick but some costeans beyond them failed to locate ore of any kind.

Last Chance (M.C. 8803).

1907—North of D.C.L. and R.S.B. Exact location doubtful. Included in Polygonic.

Little Hero (M.C. 7408).

1905—Included in Polygonic.

Both the Ruby and the Natives zones crop on this piece of ground. A little shallow trenching has been done and a shaft was sunk 30 ft. on the southern-most vein, which where exposed at the surface is 8 in. thick.

Little Nell (M.C. 7242).

1904—Surrounded by Polygonic. Lately purchased from Clark and party by the Irvinebank Company and now let on tribute to West and party.

Both Bluff and Nell zones have been worked here and in all thirteen separate veins have been trenched.

West and party have been for some months exploiting one of the Nell veins. The shaft now 40 ft. deep is on the same shoot as that worked in the Edith, its length being 60 or 70 ft. The vein exposed in the shaft averages 18 in., and although it is looked upon as one of the best producers on the field, when inspected there happened to be little wolfram showing, but the small stope to the north-west, extending 30 ft. from the shaft at the 20-ft. level, was inaccessible to me because of breaking down being in progress. On the south-east there is little reef left between the Little Nell and Edith shafts.

Photo. 18.—Little Nell, Etc., from South-east.

The pure white quartz is regarded as barren by the tributers, who look for ironstains and mica on the walls and in the reef as wolfram indicators. "Speckled ore" is preferred to any, blocks of wolfram up to 70 lb. in weight being sometimes found in it.

Clark is said to have won 14 or 15 tons from this claim (of this 3 tons came from the tributers' shaft), but the only amount officially recorded is that of 11/20 ton sold in 1904 for £30. The company's tributers during 1912 treated 353 tons of stone, producing 5 6/20 tons of wolfram, valued at £483. The average wolfram content is thus only 1½ per cent.

Little Nell (M.C. 9751).

1910—North-west of Hurry Up. Abandoned.

A few trenches only have been opened on this ground.

Lone Hand (M.C. 7270).

1904—Between Mount Carbine No. 1, Polygonic, Lucky Hit, and X Rays. Now held by Johnson.

Two veins of the Iolanthe zone have been worked on this claim. On the southern there are two caved cuts and three inaccessible shafts, believed to be 30 ft. deep, between which some stoping has been done.

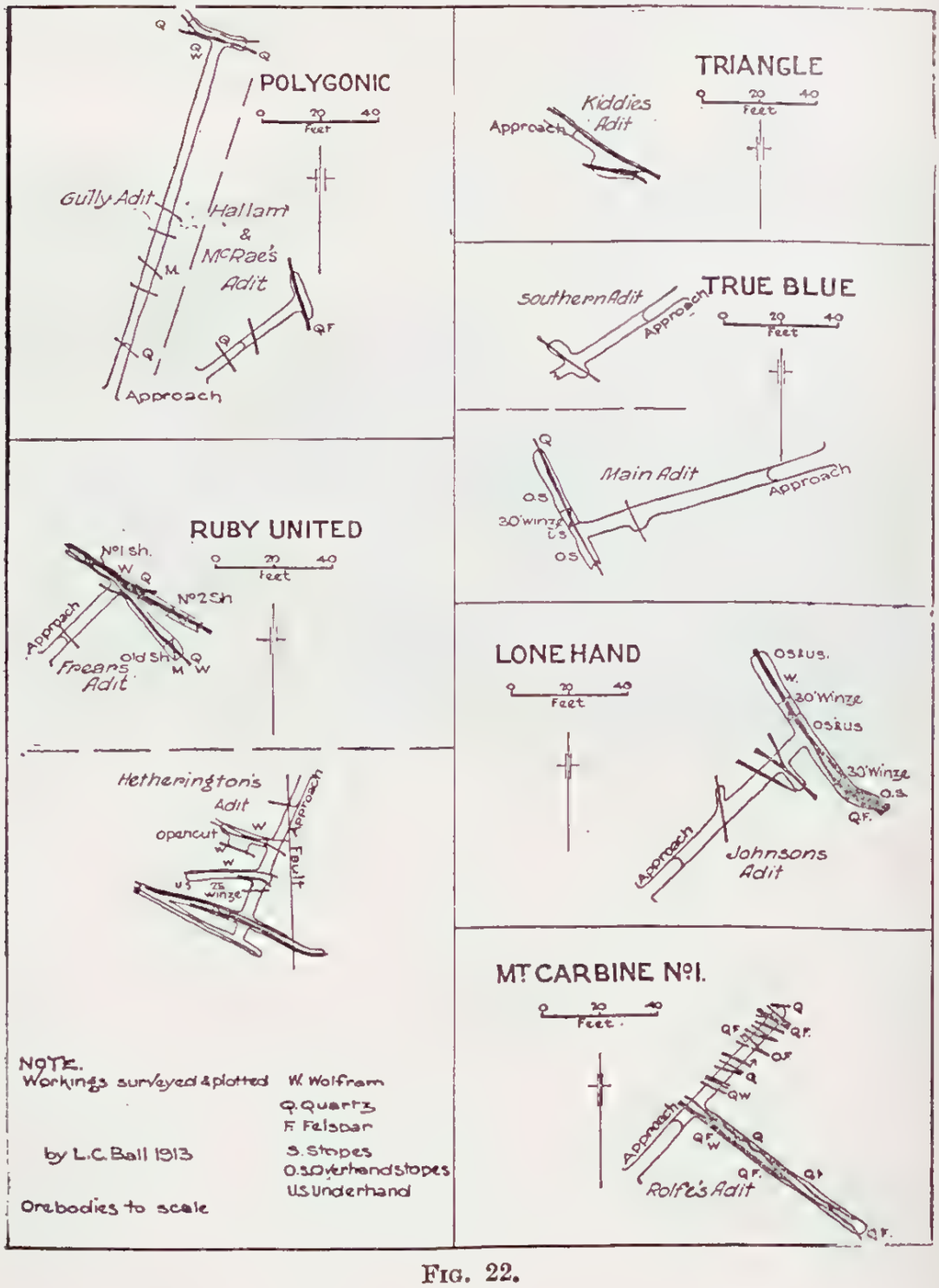


FIG. 22.

The main line is near the northern boundary of the claim and on it five shafts have been sunk. There is also an opencut or underhand stope 40 ft. deep; and the lower workings have been tapped by an adit 80 ft. in length, which crosses in all six veins, the first and last being those already mentioned. The inner workings comprise drives 40 ft. to the north-west and the same distance to the south-east, in each of which is a 30-ft. winze and from the bottom of which a vein from 2 ft. to 3 ft. thick has been stoped over the whole length of the drives. Above the drives also a little stoping has been done. That one man should be doing such work is almost incredible, the only point in his favour being the nature of the ground, which needs little or no supporting timber. Neither in the ore nor on the walls is mica to be seen, but the wolfram-bearing ore is always iron-stained, and the richest is found where the reef bulges near a bifurcation. (*See* Fig. 22.)

Johnson's output for the last four years amounts to 8 tons, most of which came from the surface.

Lorna (A.C. 9480).

1909—Bock's Gully. Abandoned.

Exact location not given, but believed to be below the Polygonic.

Loty Mary (M.C. 7245).

1904—Unlocated. Abandoned.

Lubra (M.C. 9758).

1910—North-western end, ¼-mile west of the Jubilee. Abandoned.

Exact location doubtful, but believed to be on the Paw Paw zone.

Lucky Hit (M.C. 7442).

1905—Between Polygonic and X Rays. Formerly Heyer; now held by Walsh.

No reefing has been done here, but, over the greater part of the claim, the whole surface has been turned over and stripped to a depth of 5 or 6 ft. Just now a wages man is employed stripping 3 to 5 ft. of soil and subsoil in the south-eastern corner, but he reports the ground to be poor.

Macdonald.

19— —¼-mile north-west of the True Blue. Claim not registered. Abandoned.

The few shallow cuts opened on small leaders here have caved in. A shaft has been sunk 20 ft. on a 5-in. leader of iron-

stained crystalline quartz carrying a little wolfram. The veins here are abnormal in trending with the lamination of the schist and also in their drusy cavities.

McManis.

19— —Probably unregistered.

This claim lay on the south-eastern side of the Daisy United, near the summit of Carbine Hill. There are a number of holes and trenches and one caved opencut (with possibly a caved adit). These are on small leaders which as now exposed are not more than 6 in. in thickness and seldom run for more than 10 ft. until they pinch out, but the workings give good sections showing the almost invariable presence of an overlapping vein within a few feet or inches of the one that has petered out.

Mary Jane (M.C. 8675).

1907—D.C.L.?

Mona (M.C. 7287).

1904—Bock's Gully. Included in Polygonic.

The north-western end of the Iolanthe zone is just within this ground. There is an old shaft, in which water now stands 25 ft. below the surface; there are also other old workings filled in during the working over of the old mullock tips. It would seem that the floater ground below the crops was rich, as it has been stripped in one place to a depth of 8 ft. right down to the gully bottom.

The company during 1909, 1910, and 1911 produced 1 11/20 tons wolfram, valued at £154.

Mona's Luck (M.C. 9784).

1910—Included in Polygonic.

Very little work has been done on this part of the lease.

Mon Repos (M.C. 7389).

1905—Included in Tungsten.

Two large caved opencuts have been opened on the north-western end of the Bluff zone, one of them being really a continuation of the D.C.L. cut. The veins are small and taper out within a short distance to the north-west.

Moonstone Natives (M.C. 8762).

1907—On northern boundary of Johnson. Abandoned.

The large cut on the boundary of the Johnson was continued into this holding, where the leaders, several of which are showing,

have thinned down below what could be profitably exploited. Another cut has, however, been carried northwards on what must be a cross vein, as the general trend of the veins hereabouts is north-westwards.

Mount Carbine (M.C. 7152).

1904—Included in Nil Desperandum.

This ground adjoins the Johnson, and on it both the Johnson and Nil zones have been worked, the former by adit and shaft as well as opencut and trench.

Mount Carbine (A.C. 9956).

1911—Unlocated. Abandoned.

Mount Carbine No. 1 (M.L. 2225).

1905—South-eastern end of the hill.

This includes Baird's Bluff, the first ground pegged out on the field. After being forfeited by Baird, the ground was applied for as a lease by a Port Douglas syndicate, and an attempt was made to work it, but without success. Subsequently the Irvine-bank Company was approached and given two-thirds interest (later increased by purchase to thirteen-eighteenths) in the

PHOTO. 19.—MOUNT CARBINE NO. 1 DUMPS.
VIEWED FROM D.C.L.

holding conditionally on its erecting a mill, mining, and crushing the ore, and paying one-third of any profits to the syndicate, which retained one-third interest without liability. It is rumoured that £5,000 has been refused by the syndicate for its interest.

The Syndicate lease is now the main source of supply for the company's mill; and all the work done is on Bluff veins, but it is certain that the Nell will also be found in the north-eastern part. Rolfe's adit proves the Bluff veins to be of little value in the western part of the claim, but it has not been driven far enough to intersect the main veins of the Nell. (*See* Fig. 22.)

The opencuts, that in places pass down into as yet unfilled stopes, are a conspicuous feature of the hill. Most of them, though deep, are only a few feet wide, but in some places where the veins have come together the cuts are between 20 and 30 ft. across; and from end to end the great cut has a length of 6 chains. Most of the veins occur within a width of 50 ft., but there are several others to the south of the great cut on which some work has been done.

PHOTO. 20.—MAIN OPENCUT ON MOUNT CARBINE No. 1.
VIEWED FROM NORTH-WEST.

The veins are now being exploited by overhand stoping from drives driven along them off the superimposed adits known as No. 1 and No. 3 (the mouth of the latter being on the Poly-

gonic). These are connected with one another by shafts and stopes, and a rise from the mill adit connects the latter with No. 1. Ventilation is thus much facilitated, and conditions underground are consequently all that could be desired.

No. 1 adit is 172 ft. long, and from it seven drives, with an average length of 35 ft., run north-westwards, and six drives run south-eastwards, their average length being 140 ft. In all, 28 veins are crossed by the adit, the variation in width being between 1 in. and 3 ft. The total thickness is 17½ ft., but only one vein is over 18 in. in thickness. In the drives the veins are as much as

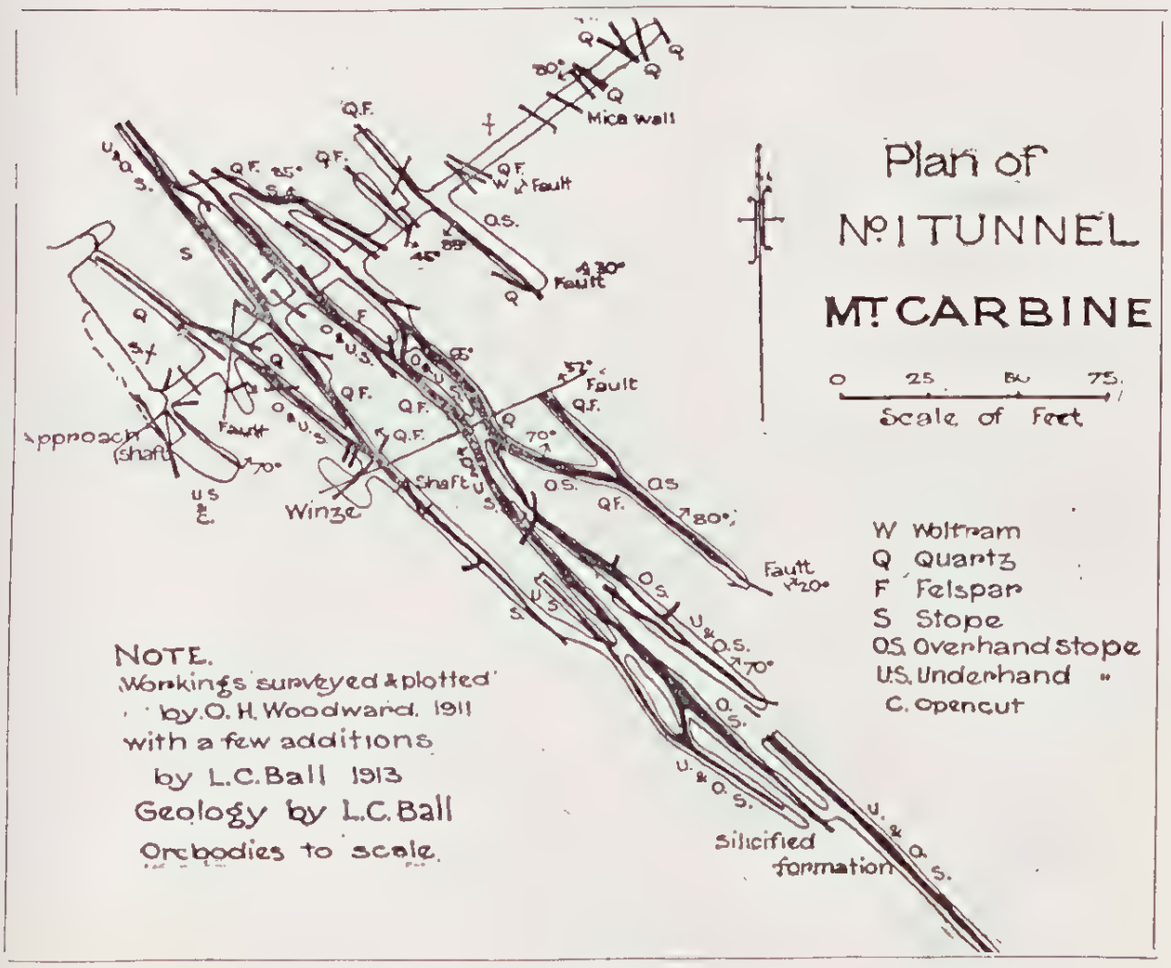


Fig 23.

4 ft. thick. Though much underhand and overhead stoping has been done, there are abundant opportunities for observation of the nature of the veins, their gangues, inclusions, branchings, overlaps, and faultings on joint planes. The dump is known to contain much ore that it would pay to treat, and to get at this a rise is being put up from the No. 3 adit level so that ore can be run directly to the mill. (See Fig. 18.)

No. 3 adit is 245 ft. long with four drives averaging 90 ft. in length on the north-west, and seven drives averaging 200 ft. in length on the south-east. The number of veins crossed, as

in No. 1 adit, is 22, of which the smallest is 1½ in., and the largest 4 ft. The combined thickness is 18½ ft., and omitting those veins under 18 in. wide, there is still a total of 10 ft. There have been great increases in the drives to the south-east, one vein reaching 5 and 6 ft., with 2 ft. 6 in. to 3 ft. averages over long distances. The best faces showing at the time of my visit were those in the stope, 13 ft. above the 180 ft. south-east drive off No. 3 adit, where a vein of quartz and felspar is from 2 ft. to 2 ft. 6 in. thick, and carries 10 per cent. wolfram. Mr. West points out the 209 ft. south-east drive within 50 ft. of the adit as having been the richest part of the mine. The reef there was 3 ft. wide, and for 40 ft. along the drive the stone averaged 11 per cent. wolfram. Underhand stoping has not been initiated here yet, because the reserves between this level and the surface are still being exploited. (*See* Fig. 24.)

A winze has been sunk 100 ft. beneath the adit level from the 189 ft. south-east drive. The reef above was 8 ft. wide, and at 20 ft. below the level it is still 6 ft. wide, consisting chiefly of quartz with some felspar and traces of wolfram. At 48 ft. down it was faulted its own width and tapered slightly. At 58 ft. depth, where the main reef has decreased to 3 ft. 6 in., a second reef, 2 ft. 6 in. wide, came into the winze, and continued to the bottom, the main reef being left in the wall of the shaft. Mr. West informs me the reef was rich in wolfram all the way down the shaft, and he looks upon the development as highly encouraging. Water is now standing at 25 ft. below the adit level, so that was as deep as my observations could go. At the adit level that part of the reef within 6 in. of the footwall carries about 10 per cent. wolfram—a quite unusual showing for this mine.

Myrtle (M.C. 8274).

1906—Included in the Daisy United.

Native (M.C. 7236).

1904—North-west of the True Blue.

This ground or part of it was subsequently applied for at various times as the Hunter, Huntress, Ivy, and Chance. It is on the True Blue zone.

Simpson and Beadle were cleaning out Perret's old shaft, in the bottom of which wolfram is said to have been left.

Nil Desperandum (M.C. 7207).

1904—This, the first claim registered, adjoins the Mount Carbine No. 1 on the north. Included in Johnson.

This includes part of two zones—the Nil and the Johnson. The cuts on the former near the crest of the ridge have caved in, but they do not indicate that the veins worked were of any richness nor of great continuity, the most extensive being about 2 chains long, and 12 to 18 in. wide. A costean to the south-east crosses the junction of two large veins of quartz and felspar, one 2 ft. 6 in. to 4 ft., and the other 10 in. to 2 ft. 3 in. thick, the bulge at their contact being 5 ft. (See Fig. 5.) Further on a shaft has been sunk 20 ft. on the same vein, which on the adjoining claim (the Johnson) was worked opencast.

Three or more distinct veins of the Johnson zone down the slope from the Nil have been worked extensively by opencut, shaft and adit over a distance of 3 chains in the south-eastern corner of the holding (this was part of the original Mount Carbine claim), and others have been worked at intervals to the north-west, where, however, the veins seem to have become impoverished and to be petering out.

The adit affords some interesting exposures showing overlapping, branching, faulting and petering-out of the veins, which run from 6 in. to 18 in. in thickness. It is 135 ft. in length, and in its different bends exposes five separate veins, which are from 5 to 18 in. in thickness, the average of the main vein followed being 12 in. (See Fig. 17.)

The Company during 1910 and 1911 produced 2 5/20 tons wolfram, valued at £214.

Nonentity (M.C. 9729).

1910—About 1 mile north of Mount Carbine leases. Abandoned.

O.K. (M.C. 7246).

1904—Bock's Gully, below Polygonic. Abandoned.

The floater ground is said to have yielded up to 80 lb. of wolfram to the cubic yard, and Mildren is said to have taken £500 worth of mineral from the claim.

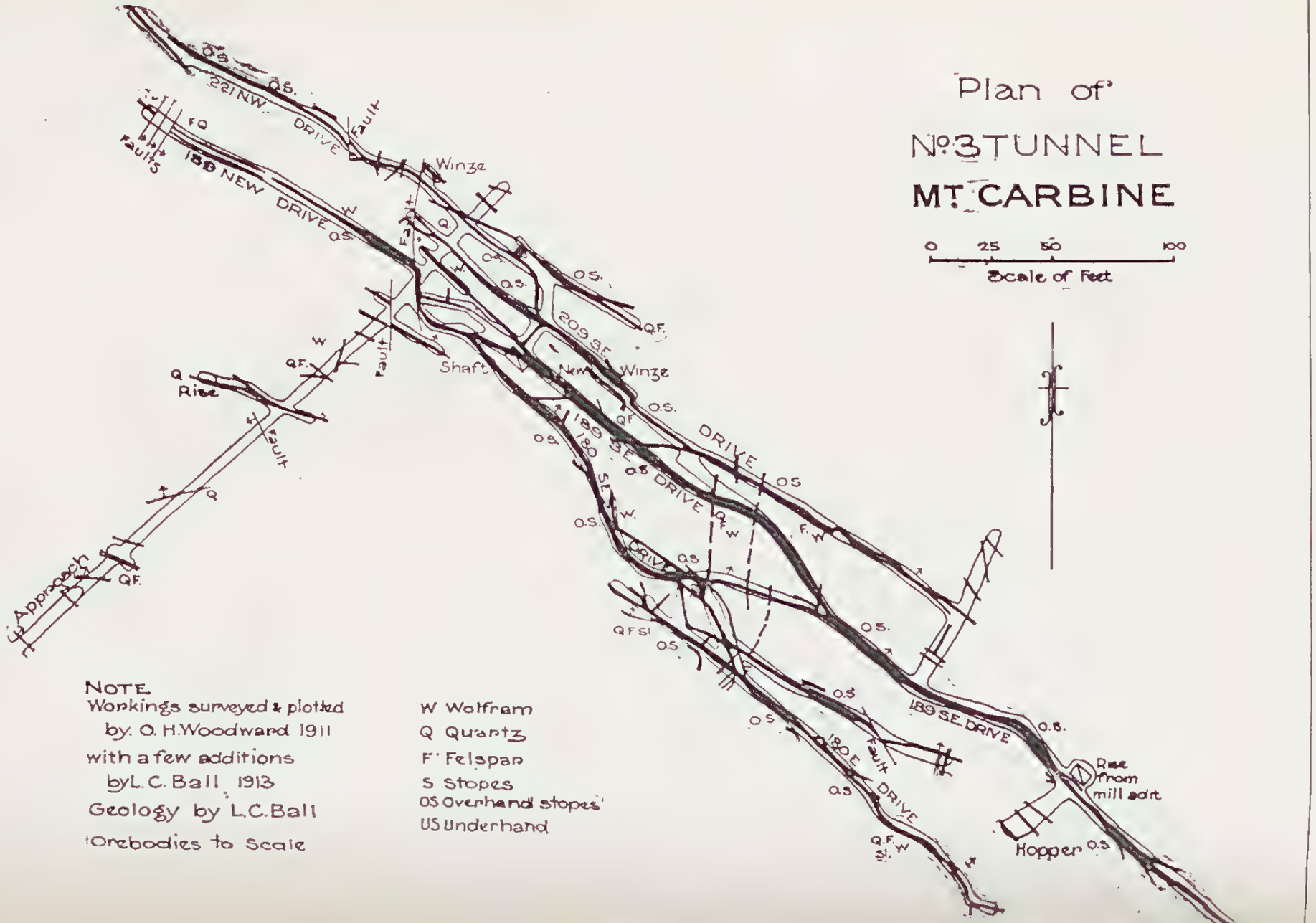
Oliver (M.L. 2979).

1907—Dam site. Re-applied for as M.L. 3150.

Pearl (M.C. 8414).

1907—Included in Gems United.

Three distinct parallel veins belonging to the Ruby zone have been worked, chiefly by opencut, though four shafts have


Plan of
No 3 TUNNEL
MT CARBINE
0 25 50 100
Scale of Feet
221 NW. DRIVE
188 NEW DRIVE
Winze
Fault
Shaft
209 SE. Winze
189 SE. DRIVE
180 SE. DRIVE
Rise
Approach
Rise from mill adit
Hopper
NOTE.
Workings surveyed & plotted by O. H. Woodward 1911
with a few additions by L. C. Ball 1913
Geology by L. C. Ball
Orebodies to Scale
W Wolfram
Q Quartz
F Felspar
S Stopes
OS Overhand stopes
US Underhand

been sunk; two of them (Trahey's No. 1 and No. 2) near the Ruby boundary being 54 ft. deep, Trahey's No. 3 being 43 ft. deep, and the Company's tributer's shaft 40 ft. Owing to caving, little can now be seen, but it is patent that the veins were not large.

It is understood that the two 54-ft. shafts are connected by a crosscut and that ventilation was effected by means of a drive that broke into the Ruby workings. From No. 1 a stope was carried 50 ft. north-west and 25 ft. south-east, and similarly there were stopes on either side of No. 2 shaft which has caved in.

Phœnix (M.C. 8811).

1907—" 1 mile north of Mount Carbine." Abandoned.

Pianto's.

1911—Unregistered. Abandoned.

Pianto's workings are in the granite about ½ mile east of the main workings on Carbine Hill. A vein 9 to 12 in. thick is exposed by a shallow opencut. The stone now at grass is barren but presumably some wolfram was got here and traces of the mineral associated with like amounts of tinstone show in adjacent crops.

This vein and the others in the granite hereabouts trend in the same direction as those in the slate and were presumably formed at the same time.

Pick and Shovel (A.C. 9266).

1908—South-east of X Rays and down the slope from the Iolanthe. Now held by Brown.

This is in floater ground with 1 to 3 ft. sinking.

Porkey (M.C. 9792).

1910—Included in Polygonic.

The workings, including a few caved trenches, are apparently on the Johnson zone, here much attenuated, the veins exposed being only 1 to 4 in. in thickness.

Polygonic (M.L. 3283).

1911—Includes a number of claims (Mona's Luck, Little Hero, Lost Chance, Porkey, Hit or Miss, Poverty, Mona, and Dead Finish), lately acquired by the Irvinebank Company.

Most of the vein zones should cross this elongated piece of ground; but only the Ruby and Iolanthe have been worked to

any extent, although rich ore has been won on the R.S.B. and Little Nell on either side. Thus the adit in the gully between the R.S.B. and Ruby United in a distance of 135 ft. cut seven leaders, most of them less than 3 in. thick and only one reaching 12 in. This last carries a little wolfram, and 18 ft. of driving was done on it with little result.

The old Gems United workings (described under other headings) extend nearly across the northern end of the lease; and from the amount of work done, one should judge that the returns were fair.

On the southern part of the lease in the old Mona claim rich shoad ground was worked on Bock's Gully and a little mining was done on the Iolanthe line; and again some surfacing has been done on the old Dead Finish claim, where also one of the Iolanthe reefs has been exploited by opencut, shaft, and adit. The reef in the adit was from 15 to 18 in. wide, and it appears to be worth following to the south-east. (See Fig. 22.)

The company during 1911 and 1912 produced 4 tons wolfram, valued at £391.

Rolfe's adit is about 70 ft. long, and it crosses 17 veins of the Bluff zone, these being 1 in. to 20 in. in thickness. The total reef thickness is 8½ ft., but only two are greater than 18 in. One of these, 10 ft. from the mouth of the adit, has been followed for 90 ft. to the south-east, but the vein gradually thinned out to 6 in. in the face. The other, near the end of the adit, should now be prospected, and the adit itself should be extended to prove the Nell veins ahead.

The company, between May, 1907, and the end of 1912, sold 577 15/20 tons wolfram from this ground, the value being £54,134. Since 1910, there has been treated 23,596 5/20 tons of ore, yielding 408 5/2 tons wolfram, included in the above sum.

Poverty (A.C. 7975).

1906—"East side of Mount Carbine." Abandoned.

Poverty (A.C. 7519).

1905—Bock's Gully. Abandoned.

Red Cap (M.C. 7278.)

1904—" 1½ mile north of Mount Carbine." Abandoned.

The mine is on the western side of a hill ½ mile to the north of Carbine Hill's summit.

The two parallel veins agree in trend with those of Mount Carbine, but the character of the country rock has changed, the slate being here distinctly epidotic in character, this causing it to be extremely hard and difficult to mine. Two shafts have been sunk a little over a chain apart on the main line, and the caved cuts extend a distance of more than three chains, but little can be seen of the occurrence of the reef because of a thick overgrowth of grass and weeds. The stone left at the brace shows that some chalcopyrite occurs with the wolfram here. Though the mine was worked by Boreham for several years, he informed me that the deepest shaft does not reach more than 33 ft. beneath the surface (where, however, he reported wolfram still showing). At the north-western shaft 3 tons of wolfram was got near the surface and 1½ ton in sinking, and from the south-eastern shaft a total of 3 tons was got (1 1/20 tons near the surface). A third shaft on a 6-in. leader 3 chains to the south-west of the above yielded 18/20 ton wolfram.

The total yield from the claim was 12 15/20 tons (*fide* Mr. Boreham).

Rolfe (M.L. 2878.)

1907—Taken up by the Irvinebank Company on the northern side of the Johnson to protect the dump at No. 2 adit.

Only one or two small trenches have been opened.

R.S.B. (M.C. 9426).

1909—Between the D.C.L. and Polygonic. Now held by White.

A number of leaders of the Bluff and perhaps also the Nell and Iolanthe zones have been exploited here.

The Nell workings in the northern part of the claim are unimportant, comprising only a few caved trenches, a cut, and a short adit. The veins are small and do not extend far.

The Iolanthe (?) veins in the southern part have been deeply opencut and trenched, and besides three shafts now caved or flooded have been sunk, while there is also a caved adit along one of the veins. The veins now showing are from 3 to 13 in. thick.

White's present workings are on the Bluff zone, here consisting of the usual network of branching and overlapping leaders. The opencuts have been filled in, but one of the two 30-ft. shafts is in use and was descended. At 10 ft. depth drives run off to the north-west, and much stoping has been done for a yield of 10 tons wolfram. At the bottom there are drives north-

west and south-east, respectively 20 and 30 ft., on a 9-in. vein of iron and slightly copper-stained quartz carrying blady laths of wolfram much stained by ochre. The yield from the 35 ft. of driving is 2½ tons of stone, believed to carry 15 per cent. wolfram, which should just about afford wages.

The total production of the claim is estimated by Mr. White at 20 tons of wolfram.

Ruby (M.C. 7261).

1904—Included in Ruby United.

Ruby (M.C. 7876).

1906—Included in Ruby United.

Ruby No. 1 (M.C. 9376).

1909—Included in Ruby United.

Ruby United (M.C. 9587).

1909—At northern end of the Polygonic. Now held by Hetherington and Frear.

Several veins have been tried here all belonging to the Ruby zone, but only two or three have been worked extensively, first of all by open cuts (now caved), then by shafts (of which there are seven, all now inaccessible), and lastly by adits, of which there are two, one on either side of the Hill. These workings extend from end to end of the claim, and the amount of work done by two men in seven years is surprising. The innermost of the adit veins is the most continuous on this claim, it having been followed through the Ruby and also the Pearl. The others are made up of a series of overlapping leases.

The south-eastern part of the claim (formerly the Ruby No. 1) does not give much promise. The cuts which are caved show only small lenticular leaders and the four shafts, the deepest of which is only 20 ft., are inaccessible.

In the north-western part (the original Ruby), where there are three main reefs, the shafts are much deeper, No. 1 being 58 ft., No. 2 54 ft., and No. 3 97 ft. The last is connected with Trahey's No. 1 on the Gems United for ventilation. The mullock tips of this claim are outstanding landmarks; and, as they contain a little wolfram throughout (the exact percentage has never been determined), they will probably be retreated in time to come.

These old shaft workings have now been made accessible by the two adits. Frear's adit is 30 ft. long, and it meets the main reef between No. 1 and No. 2 shafts, where 2 ft. 6 in. thick. In the drives to the north-west and south-east it splits and gradually thins down, but as wolfram is showing in several places more work will be done here in the future. (See Fig. 22.)

Hetherington's adit is 63 ft. long, and four separate drives run off from it; the two outer for 30 ft. to the west, an inner drive for 53 ft. to the west-north-west and 12 ft. to the east-south-east, and the main drive for 80 ft. to the west-north-west and 35 ft. east-south-east. In the outermost drive three small leaders were followed, and being rich in wolfram, were stoped out to the surface. In the next drive two small leaders were followed. The main drive is on two leaders, 3 ft. 6 in. apart, one of them 7 in. and the other 9 to 12 in. thick. Good wolfram was got here, and much of the stoping done has been above and below the north-western drive. (See Fig. 22.)

A stope extends 20 ft. to the south-east of the No. 1 shaft and north-westwards to No. 2, which connects by stope with No. 3 shaft, and this again by a short crosscut at the 66 ft. level with the adit. The reef was 3 ft. wide at the collar of No. 3 shaft, but the average below was 18 in.

Mr. Hetherington estimates the total production of the Ruby United to be between 27 and 30 tons wolfram.

St. Patrick (M.C. 7415).

1905—Included in Catherine, q.v.

Saxon (M.C. 8984).

1907—"Mount Carbine." Abandoned.

Scheelite Gully.

Scheelite Gully is on the eastern slope of Carbine Hill, and lies about a quarter of a mile north of the mill. The name is derived from the fact that much scheelite has been got on the surface here, and a few hundredweight of the mineral was obtained as late as 1912. Of the many alluvial claims pegged out here none seems to have been registered. Fitzgerald did some work on the leaders in the bed and on either side of the gully during 1912.

The veins which belong to the Iron Duke zone are hereabouts extremely irregular both in trend and size, apparently because of their deposition along intersecting joint planes. They are never more than 12 in. thick, and the quartz is associated with so much country that the material is rather "formation" than ore.

One shaft now used as a well has been sunk 30 ft., and some stoping has been done beside it. The cuts have been filled in as worked, and in the ends only small and irregular leaders are showing.

Scottish Queen (M.C. 7271).

1904—Included in the Tungsten.

The above ground is at the north-western end of the Bluff zone, of which three separate veins have been here exploited by cuts or trenches; and on one of them (9 in. thick) two shafts were sunk and some stoping done.

Sloper (M.C. 8516).

1907—Included in Ruby United.

Smoker (M.C. 8945).

1907—"North-east of Mount Carbine." Abandoned.

Struggle (M.C. 9312).

1908—"South-western side of Mona," Bock's Gully. Lately held by Grogan.

This is believed to have been out on the flat to the west of the gully, where much stripping 2 to 5 ft. deep has been done, but where there are still many blocks untouched.

Struggle (M.C. 9756).

1910—Adjoining the Battler, Bock's Gully. Abandoned.

Sundet's Gossan Blow.

19— —Not pegged out

This crop is on the flat at the north-western end of the field 30 ch. west of the Redcap. A shallow hole exposes 3 ft. width of siliceous manganiferous material, including silicified country and traces of rhodonite. It is believed to carry traces of gold and silver, but though there was once a project on foot to sink 100

ft. on it there is little encouragement. As elsewhere noted, the formation is probably due to cooled magmatic solutions such as those that brought in the tungsten, and it is not unlikely that wolfram may occur in depth here.

Tailings (M.C. 9314).

1908—Manganese Creek below township, near recreation reserve. Abandoned.

This was taken up for the retreatment of tailings from a little sluicing done by the company.

Tom Thumb (M.C. 8641).

1907—"Two hundred yards south of Mona." Probably on Bock's Gully. Abandoned.

Triangle (M.C. 7238).

1904—Between Edith, Polygonic, and Mount Carbine No. 1. Now held by Kiddy and party.

The alluvial along Bock's Gully in the lower end of this claim is said to have been very rich in wolfram, as much as 60 lb. to the yard having been reported.

Between 20 and 30 veins of the Nell and Bluff zones have been exposed by shallow cuts on this claim; but the chief workings are in the southern part, where two separate series of veins have been opencut and sunk upon by shaft. One of these shafts is 65 ft. deep and the other 30 ft., but neither was made accessible to me. Mr. Kiddy states that there is a 2-ft. vein at the bottom of the 65-ft. shaft, where, however, it happens to be poor just now. A short adit at the end of one of the southern cuts exposes two veins 7 to 15 in. in thickness, both of which contain good wolfram, but cannot further be profitably underhand stoped. (See Fig. 22.) It is now proposed to put an adit in from one of the lowest cuts, whereby a number of the known reefs will be intersected and backs will be made available.

Of late the claim holders have been doing well, making an average of £5 per man per week. The production of the last eight years Mr. Kiddy estimates as 35 tons, but the yield prior to 1904 is not known.

True Blue Extended (M.C. 9393).

1909—At north-western end of the hill. Included Keating's. Abandoned.

In order to get at the vein worked by Keating (q.v.), Simpson, at a point 60 ft. below the cap, put an adit in 80 ft., then drove 40 ft. north-west and 65 ft. south-east, and then stoped up; but most of the work was unremunerative, as only one rich patch of wolfram (14/20 ton) was struck. Subsequently another party sunk a winze 30 ft. in hard ground for a small return. In the face of the north-western drive the vein is 6 in. thick. (See Fig. 22.)

A second adit, Perrett's, a little more than a chain south of Simpson's, has been partly filled in, but in the outer portion there is a 6-in. vein showing. Perrett is said to have got 9/20 ton of wolfram from this adit.

The total yield for the claim would seem to have been less than 9 tons.

Try Again (M.C. 8148).

1906—"Mount Carbine." Abandoned.

Try Again (M.C. 9960).

1911—North of Johnson. Abandoned.

Small 6 to 12-in. lenticular veins have been deeply trenched, but there is no evidence of rich ore having been got.

Tungsten (M.L. 3174).

1910—North-west of the Polygonic and D.C.L. Includes Scottish Queen, Just in Time, Ida, Hopeful, Mon Repos, Phœnix, and part of Bismark. Now held by the Irvinebank Company.

The Ruby and Bluff zones have been worked but not to a large extent, comprising as the workings do only shallow shafts and a few opencuts, though there are numerous trenches. Owing to the usual caving and filling in little can be seen of the veins, none of which, however, can have been of large size.

Venture (A.C. 8856).

1907—"¼ mile north-west of Mount Carbine." Abandoned.

Vera (M.C. ?).

1912—Includes Crow's Nest. Now held by Asmus and Lovell.

This claim is being worked for tin which occurs chiefly in greisenised country along fissures in intrusive granite; but a little wolfram has been got in neighbouring gullies, and one irregular mass of quartz in the unaltered granite carried a little molybdenite.

Wayback (M.C. 9443).

1909—Included in Johnson.

Four or more separate veins of the Wayback line have been worked by a trench and opencut now caved, the thickness varying between 6 and 18 in. There is showing in the end of Christisen's cut a vertical leader 6 to 12 in. thick, poor in "metal." Also the mill adit passes through the claim exposing three veins respectively 2 in., 6 in., and 2 ft. in thickness.

The Irvinebank Company during 1911 produced 10/20 ton wolfram valued at £48.

Wellbeck Abbey (M.L. 3073).

1908—South of Lucky Hit. Taken up by the Irvinebank Company, but later abandoned.

A little surfacing has been done in the northern part of this ground.

Whistler (A.C. 7457).

1905—"Mount Carbine." Abandoned.

White Elephant (A.C. 8823).

1907—"Included in Eye Opener."

Wolfram Crown (M.C. 9122).

1908—Included in Johnson.

The Dazzler zone failed just on the eastern end of this ground, but there is an offshoot from the Nil zone that has been trenched and potholed almost from corner to corner. This is in one place 18 in. thick, but generally less than 6 in., so is unimportant.

X Rays (M.C. 7463).

1905—Included in X Rays Extended.

X Rays Extended (A.C. 7709).

1905—South of Mount Carbine No. 1. Now held by Johnson and Martin.

The greater part of this claim has been surfaced during periods of high market prices, usually to a depth of only 3 ft For this operation as many as 30 or 40 wages men have been temporarily employed on the claim. Johnson at the end of the year was stripping single-handed 8 to 10 ft. ground near the centre in preparation for the advent of the wet season, when

the whole paddock would be ground sluiced. The claim holder expects a yield of 3 oz. to the dish (equivalent to 1 per cent.), but it is not generally believed that the ground can average ½ per cent.

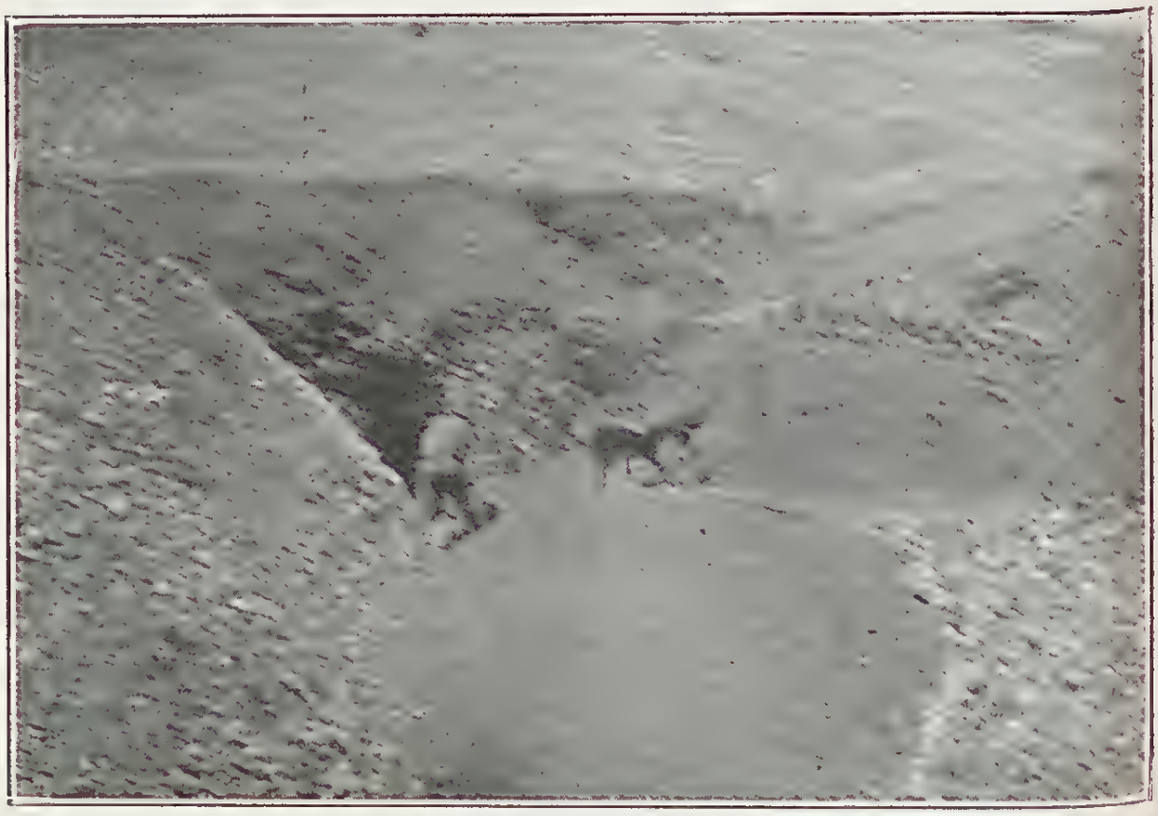


PHOTO. 21.—STRIPPING FLOATER GROUND ON X-RAYS.

In the northern part of the claim, where one of the Iolanthe veins has been opencut, a tribute party (Williamson and Sorenson) has sunk a shaft 50 ft., and is now engaged in stoping a 15-in. vein. The men are making good wages, the stone when picked averaging 7 per cent. wolfram.

Mr. Johnson estimates the total production of the claim as 40 tons of wolfram.

X Rays East (A.C. 8922).

1907—South-east of X Rays Extended, with which combined.

Brisbane, February, 1913.

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(B. DUNSTAN, CHIEF GOVERNMENT GEOLOGIST.)

PUBLICATION No. 254.

The Glossopteris Beds of Betts's Creek, Northern Queensland.

BY

J. H. REID, A.S.T.C.,

FIFTH GOVERNMENT GEOLOGIST.

With 2 Plates and 4 Text-figures.

BRISBANE:

BY AUTHORITY: ANTHONY JAMES CUMMING, GOVERNMENT PRINTER.

1916.

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The Glossopteris Beds of Betts's Creek, Northern Queensland

By J. H. REID, A.S.T.C.

INTRODUCTORY NOTE.

By B. DUNSTAN, Chief Government Geologist.

The following report by Mr. J. H. Reid places on record the results of observations made by him in an area of Permo-Carboniferous rocks at Betts's Creek near the Great Dividing Range on the Northern Railway.

The old theory that the formation containing *Glossopteris* in this locality is Cretaceous has long been disbelieved, and it is very satisfactory to know that Mr. Reid has been able to clearly remove all doubt on the matter.

In the following pages references are frequently made by Mr. Reid to the old term "Desert Sandstone," and this is hardly avoidable in view of its long usage and the numerous reports published on the subject. Our recent observations, however, show that the term is applicable to formations belonging to as many as five different geological horizons, so that it is necessary to fix the exact position of the "Desert Sandstone" referred to.

On our Geological Map of Queensland, the latest edition of which was published in 1905 (G.S.Q. Pub. 217) the beds about Betts's Creek are shown as "Desert Sandstone," this area being a portion of the series extending south-easterly along the Dividing Range between the Great Northern and the Central Railway lines.

Away to the north-west of Betts's Creek another formation termed "Blythedale Braystones" extends towards Croydon and the Gulf of Carpentaria, while a third area of "Desert Sandstone" in Cape York Peninsula reaches from the Mitchell River to Torres Straits.

The beds between Betts's Creek and Croydon have been recently shown to be much smaller than indicated on the geological map, and also to have characteristics so much in common with the " Desert Sandstone " to the south-east of the Betts's Creek area that there is every justification for including both these and the Cape York beds in the one series or formation.

In the northern part of the State the same beds have also been shown to extend south-easterly from the Central Railway along the Great Dividing Range, where they are identical with the beds forming the coal measures in the vicinity of Forest Vale, Roma, Chinchilla, and other places on the Darling Downs, and which are simply extensions of the Walloon Series further south-east near Ipswich.

The whole Walloon belt, as it might be called, is therefore one of great persistence and of enormous length, extending from the extreme northerly point of the Cape York Peninsula to the Macpherson Range on the border between New South Wales and Queensland, a distance of 1,300 miles. In the recent classification we have placed the series as Jurassic, lying conformably above the Triassic (Bundamba) Sandstones.

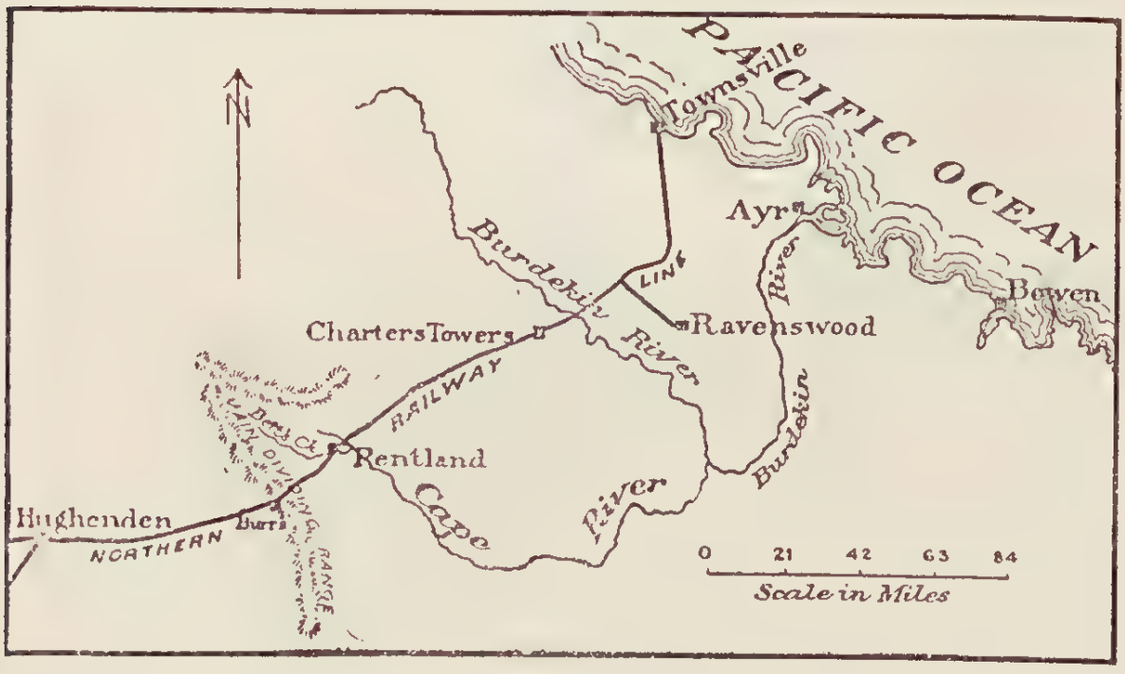
The question of artesian water is one closely associated with this series, as all the outcrops along the line of beds appear to be the intake for the artesian water. Although Mr. Reid makes no mention of it, the report by Mr. Marks on the Betts's Creek area refers to the undoubted occurrence of *Glossopteris* in beds which the author considers to be in the artesian water system, but Mr. Reid's observations, in showing the *Glossopteris* beds to be Permo-Carboniferous, leaves a very great doubt as to their being part of the artesian system. Further research on this point will be very welcome when the artesian intake beds in this district are being geologically examined.

THE GLOSSOPTERIS BEDS OF BETTS'S CREEK.

Locality.

In April, 1914, being at Pentland, I embraced the opportunity of inspecting the *Glossopteris* beds on Betts's Creek, to which Mr. W. H. Rands had assigned a Cretaceous age, considering them to belong to the Desert Sandstone series.* I was accompanied by Police Constable Regan, of Pentland, whom I have to thank for guiding me to the vicinity indicated in Mr. Rands's report.

The beds in question lie about 12 miles south-west of Pentland (148 miles by rail from Townsville), and were reached by following a rough track *viâ* Norwood to the "Nine Mile," a point on Betts's Creek. Here bluffs of red sandstone formed the creek banks, and following the creek upstream for about 2 miles, a point was reached where a tributary creek came in from the south-west.



G.S.Q. Pub 254.

Locality Map.

This part of the country does not appear to have been surveyed, and no maps obtainable at the Lands Office at Charters Towers showed this creek. However, little difficulty was experienced in recognising it as Conglomerate Gully (although

* Report on Capo River Gold Fields, by W. H. Rands, Brisbane. 1891, p. 10.

residents of the district were not cognisant of the name) from the bearing and description mentioned in Mr. Rands's report. At its confluence with Betts's Creek, conglomerates were developed, which extended up towards its source, as at that point it was running in the direction of the strike of the beds. If confirmation was needed, it was supplied by Mr. Rands's section at the mouth of the gully, which could be followed in each detail. These beds, therefore, lie about midway between Pentland and the crest of the main dividing range, and can be traced from a point about 1 mile north of Nine Mile for a distance of at least 8 miles up Betts's Creek.

Previous Literature.

In view of the evidence collected as to the age and stratigraphical relations of the beds, it is desirable to quote Mr. Rands's report, before mentioned, particularly as it is now out of print:—

"I first met with rocks of the Desert Sandstone in Betts's Creek, about 5 miles south-west of my camp, near Mount Remarkable. I have left the description of those rocks until I came to describe the Desert Sandstone formation in the neighbourhood of White Mountain Creek and Walker River, as the Flinders is called there.

"Crossing from Paddy's Gully to Betts's Creek, there is an alluvial deposit made up of quartz, quartzite, and schist pebbles, cemented together by a clayey material.

"Following up Betts's Creek to within about a mile of Conglomerate Gully, high banks of sandstone and shale are seen on the southern side of the creek. The sandstone at the base is 15 ft. thick. It is a coarse, white sandstone, with layers of quartz pebbles in it, like that generally met with in the Desert Sandstone rocks. Above this there is a layer of shale, and then alternate white and brown mud rocks.

"Above these is a bed of sandstone, and then a bed of shale full of *Glossopteris* leaves. Above this again is sandstone. The height of the bank is 40 ft. The beds are almost horizontal. I fortunately had an opportunity of submitting these fossils to Mr. R. Etheridge, jun., who pronounced them to be undoubtedly *Glossopteris*. From the character of these beds, and also from the stratigraphical position of similar beds seen in the railway cuttings on the range beyond Pentland towards Hughenden, where they certainly overlie the Rolling Downs formation, I would pronounce them to be Desert Sandstone.

"If this is the case, however, then the plant *Glossopteris* must have a much longer range in time than has hitherto been suspected, as it was supposed to be confined to the Palaeozoic rocks, or at most to range as high as the Lower Mesozoic."

Mr. Rands's conclusions so upset all preconceived ideas as to

the range of *Glossopteris* that Dr. R. L. Jack visited the locality in 1891 for the purpose of investigating the question. I quote his remarks:—†

"Mr. Rands's observations on this point seemed of so much importance that in July, 1891, I visited the scene of his discovery with a view of settling whether the beds in which he found *Glossopteris* really belonged to the Desert Sandstone.

"About a mile south-west of the junction of Paddy's Creek with Running Creek I struck Betts's Creek, which I traversed for a little over a mile to its junction with Conglomerate Gully. The latter I identified from the description on page 10 of Mr. Rands's report on the Cape, of a section of sandstones and shale. I ran up Betts's Creek for about a mile further, and then, returning to where I had first struck the creek, rode down the creek to the crossing of the old road and telegraph line from Capeville to Hughenden. Nearly horizontal conglomerates, sandstones, and shales were met with on both sides of Betts's Creek for the greater part of the distance. I was not fortunate enough to find the thin bed of shale full of *Glossopteris* leaves referred to by Mr. Rands, although in several beds of shale I could see indistinct and fragmentary plant remains, and the sandstones occasionally retained impressions of large limbs or trunks of trees.

"The sandstone rocks are traversed by the Northern Railway line from the 152¾-mile peg (from Townsville) to the 215-mile peg. At the former they overlie the auriferous schists of the Cape Goldfield, and at the latter they overlie the shales of the Rolling Downs or Lower Cretaceous Formation, in both cases unconformably. On the Flinders, as described elsewhere, they overlie the coal-bearing Lower Cretaceous rocks. There can be no doubt of the continuity of the Desert Sandstone over this immense area, and it must be accepted as an established fact that *Glossopteris*, which is abundant in the Permo-Carboniferous Coal Measures, reappears in the Desert Sandstone. As yet its presence has not been detected in the Taeniopteris-bearing Burrum beds nor in the Taeniopteris-bearing Ipswich beds, nor in the Lower Cretaceous Rolling Downs Formation.

"Whether its absence from these formations is simply due to imperfect collecting, or whether the plant really migrated from the Australian Region after Permian times, to reappear at the close of Mesozoic times, there is no evidence to show. It may any day be found in the lower members of the Mesozoic Period. A long controversy was carried on as to the age of the *Glossopteris*-bearing beds, the late Rev. W. B. Clarke and Mr. Daintree insisting that the plant was Palaeozoic—a view which received confirmation when it was found on the Bowen River, together with Productus, Spirifer, and other Palaeozoic fossils of the Lower or Marine Series of the Bowen River Coalfield; while Professor McCoy restricted the plant to the Mesozoic formations. It has been generally understood that the question has been settled triumphantly in favour of Mr. Clarke's view, but we must now admit that *Glossopteris* also, as a genus, existed in Permo-Carboniferous times, and survived till the close of the Mesozoic Period. *Glossopteris* occurs in India in Jurassic beds, and it may for some unknown reason have migrated to that country during the period in which it has been missed from Australian formations."

† Jack and Etheridge, Geol. and Pal. of Queensland. Brisbane, 1892, p. 519.

Mr. A. Gibb Maitland* regarded the beds as older than the Desert Sandstones, and considered that they were of Lower Cretaceous or even Jurassic age.

Mr. E. O. Marks, late Assistant Government Geologist, of Queensland, investigated a coal discovery higher up the course of Betts's Creek during 1910, and, although he found *Glossopteris*, he did not make any observations as to the age of the beds.†

General Geology, Topography, &c.

Betts's Creek rises in the plateau of Desert Sandstone to the west of Pentland, and flows in a course a little south of east. In its upper course it has cut through and exposed the Permo-Carboniferous beds which form gently undulating country lying between the Desert Sandstone scarps on the west and south-west and ranges of quartzite and schist on the north-east. The series of quartzites and schists are the oldest sedimentary series in the district. The quartzites form very rough country, and with the schists strike 120 deg. E. of N. and dip very steeply at angles varying from 50 deg. to 80 deg. in a direction of 30 deg. W. of S. The schists consist of phyllites, mica, and chlorite schists, the chlorite forming regular nodules. This series cuts across Betts's Creek at points about 2 miles and 6 miles, respectively, up from the junction of Conglomerate Gully, the Permo-Carboniferous beds occupying the intervening areas and also extending up the creek.

The beds there consist largely of massive and coarse conglomerates, and these appear to be the lowest visible beds of the series. They dip gently in a south-westerly direction, and, proceeding down the creek, sandstones and the *Glossopteris* shales displace them until, at a point a little above Nine Mile, they in turn are covered by flat bedded red sandstones of uncertain age, but are apparently post-Cretaceous. These sandstones continue easterly towards Pentland, and abutt against hills of quartzite. They form low ridges over the country lying between Norwood and Nine Mile.

The quartzite areas on the north-east have been deeply incised by streams; "hogbacks" are a dominant physiographical feature, and the country there is difficult to negotiate on horseback. Southwards towards the railway line the country opens out, and is easy of access, although there are only rough tracks.

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* Delimitation of Artesian Water Area North of Hughenden. Geol. Survey Publication No. 121. Brisbane, 1898.

† Geol. Survey of Queensland Publication No. 235, p. 21.

The Permo-Carboniferous series occupies a valley of erosion between the plateau of Desert Sandstone on the west, forming the main divide at an altitude of 1,800 ft. and a series of quartzite and schist hills on the north-east ranging up to heights of over 2,000 ft. Ironbark, yellow jacket, and bloodwood are almost the sole varieties of timber, but along the stream courses river gum is plentiful, and the country is thickly covered with spinifex, kangaroo, and spear grasses.

The Betts's Creek Series.

In using the term " Desert Sandstone " in referring to the formation of the sandstone plateau which forms the main divide and which lies unconformably over the Betts's Creek beds, I am simply using the name of the formation which still figures on the Queensland Geological Map for that area. Recent geological work on the main divide to the north of Roma where the Walloon formation of Jurassic age forms the crest and western flank, points to the possibility of the " Desert Sandstone " above Betts's Creek being a continuation of that formation. This is rendered more probable by my finding in these beds a specimen with the outline of *Taeniopteris* in a clay shale identical in appearance with the *Taeniopteris* shales of the Stewart's Creek Jurassic beds as pointed out by Mr. A. B. Walkom, of the Queensland University.

At Nine Mile, on Betts's Creek, the stream has cut its course through a red coarse sandstone, which forms bluffs on either bank up to 40 ft. in height. The age of these beds is uncertain, but they appear to be younger than the Desert Sandstone. The sandstone is ferruginous, felspathic, and gritty, and it lacks bedding planes but for the exception of occasional thin layers of boulders. At a distance of over 1 mile up the creek a series of clay shales, compact sandstones, and conglomerates replace the red sandstones. These I followed up a distance of several miles. I was at once struck with the dissimilarity in general appearance of these beds to the red sandstone lower down. In addition I found them to be slightly folded and slightly faulted. At a point 50 yards down stream from the junction of Conglomerate Gully there is a perfect reverse fault in the western bank, in which six distinct strata have been displaced, the upthrow amounting to about 4 ft. Below this point the beds dip in a southerly direction at about 10 deg., forming a marked unconformity in the creek with the red sandstone, although the actual junction is hidden by alluvium.

(*a*) Lithology.

The series consist of rapidly alternating beds of conglomerates, sandstones, and white clay shales. At Conglomerate Gully there is a bed of massive conglomerate about 20 ft. thick, containing boulders of quartzite and schist, while below it lies a series of sandstone and clay shales with an intercalated seam of coaly shale outcropping in the western bank of Betts's Creek. Conglomerates are abundant for several miles up the creek. White and brown shales were found at several points about 5½ miles up the creek, also dark shales containing bright bituminous particles disseminated through them. This is probably near the locality examined by Mr. Marks.

The higher beds of the series—*i.e.*, those outcropping to the south of Conglomerate Gully—consisted mostly of clay shales and sandstones. In a gully branching off on the northern side of Conglomerate Gully a bed of pink tuffaceous sandstone occurs. Examined in thin section, it shows fragments of colourless pyroxene and plagioclase, and of a much-altered mineral corresponding to olivine, showing that vulcanisity was prevalent to some extent during the deposition of the strata.

I was much struck with the resemblance between some of the shales and similar beds seen in the Upper Coal Measures at Newcastle, New South Wales. Certain of the shales, although comparatively soft, had a cherty appearance, and broke with a clean conchoidal fracture, while "soapy" shales very similar to those mentioned by Professor David* were quite abundant. Yet other of the shales were beautifully laminated and contained much white mica.

The sandstones were mostly of a white colour with felspathic cement, and varied between coarse and fine-grained.

A close scrutiny of the Desert Sandstone beds, as exposed in the railway cuttings on the Divide near Burra, led me to the conclusion that only in a few individual beds is there any resemblance, while collectively the two series are dissimilar. The sandstones of each appear to have no greater resemblance to one another than that to be expected in two separate series of the same kind of rocks which have been mutually free from the influence of intense or even moderate diastrophism. The Betts's Creek sandstones are generally finer and more compact, while the "Desert Sandstone" beds in railway cuttings were very pebbly.

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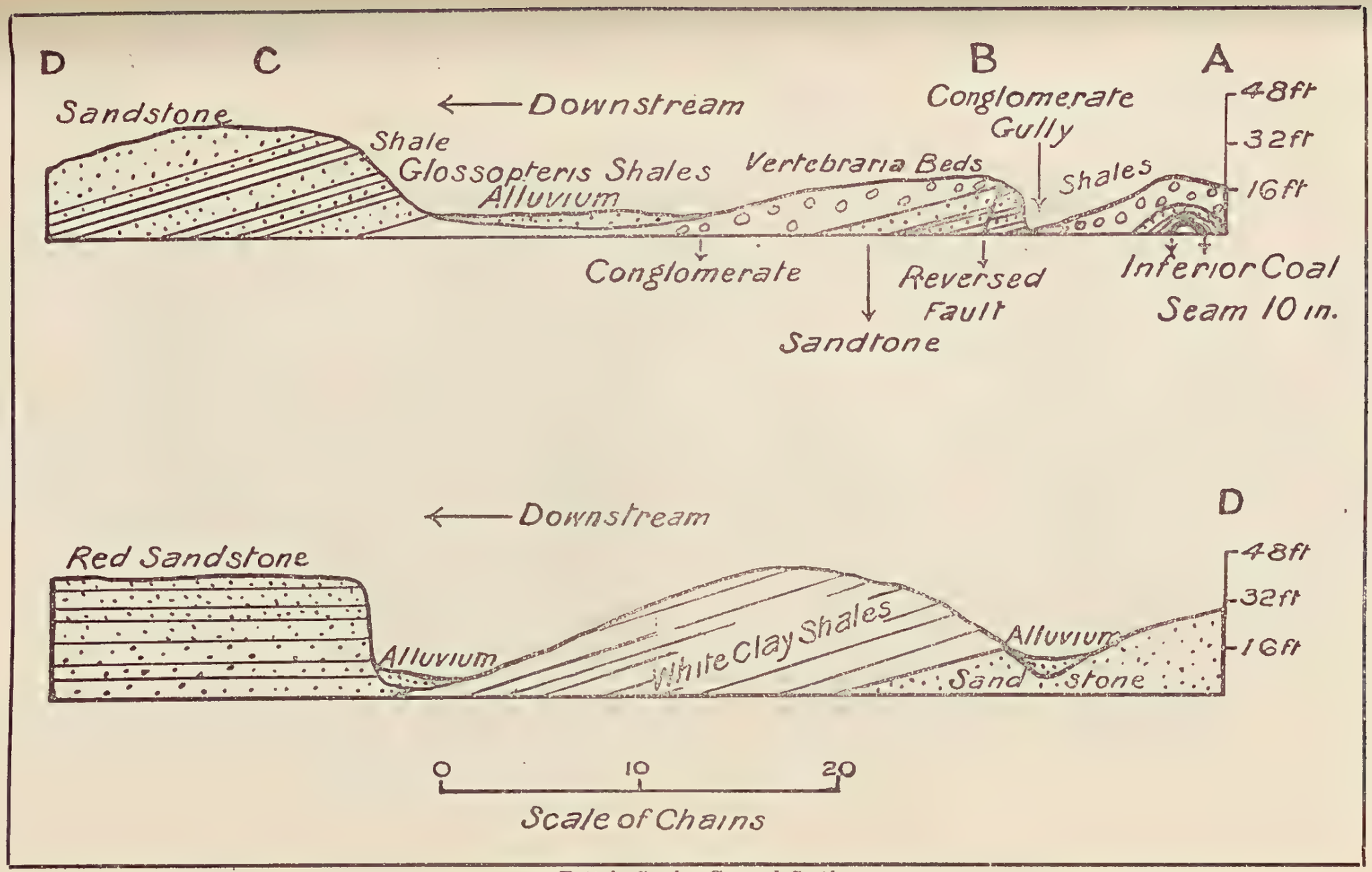
* Geol. Memoir No. 6, Hunter River Coalfield. N.S.W. Geol. Survey, Mines Dept., N.S.W.



Betts's Creek—General Section.

Fig. 2.

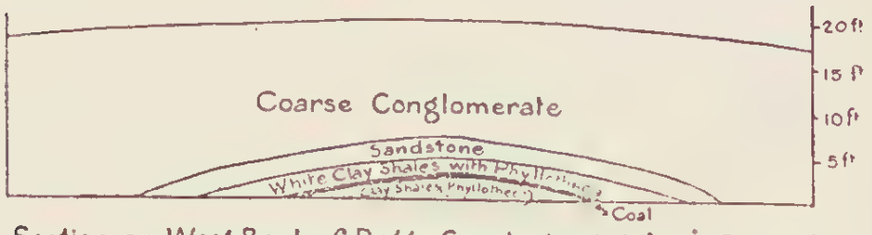
(*b*) Palaeontology.

I did not find the particular bed in which Mr. Rands found *Glossopteris*. Dr. Jack, in traversing the creek in 1891, found only indistinct and fragmentary plant remains. Mr. Marks found numerous impressions of *Glossopteris* higher up the creek.

From the shale bands within the limits of an area 6 miles by 2 miles, running along Betts's Creek, I collected the following forms:—

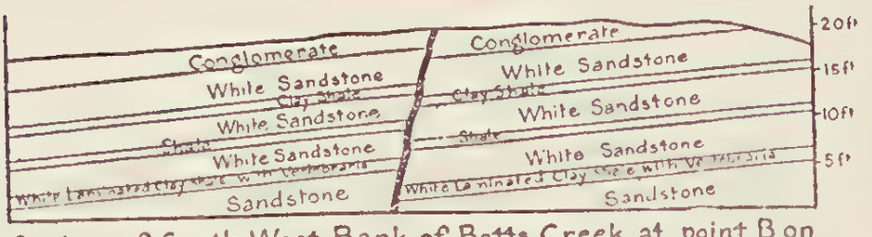
Glossopteris Browniana (Brongniart).
Glossopteris, near to *G. ampla* (Dana).
Glossopteris sp.
Vertebraria.
Phyllotheca.
Alethopteris. (?)

Section A.



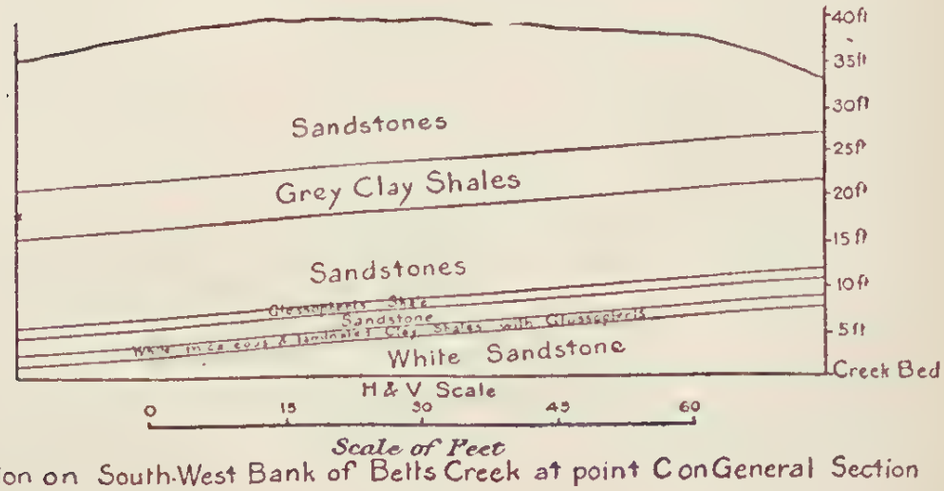
Section on West Bank of Betts Creek at point A on General Section, shewing 10 inch seam of inferior coal lying between the Phyllotheca Beds.

Section B.



Section of South West Bank of Betts Creek at point B on General Section, shewing Reverse Fault with upthrow of 4 feet

Section C.



Section on South-West Bank of Betts Creek at point C on General Section

These genera usually have distinct horizons, in which each is fairly abundant, while the others are missing or only furnish an odd specimen.

About 30 yards below the junction of Conglomerate Gully, in the same section where reverse fault is shown (see section B), there are thin beds of finely laminated white clay shale. These yielded a large number of *Vertebraria.* Strangely, *Glossopteris* was not found here, but doubtful impressions of *Phyllotheca* were present.

About half a mile down Betts's Creek a cliff, 40 ft. high, forms the west bank (see section C). At the base of this several bands of white, micaceous, and laminated clay shales are intercalated with the sandstones, and these I found to be crowded with at least two species of *Glossopteris.* One form, from its large frond (6 cm. broad), closely sub-parallel nerves, and narrow elongated meshes, falls very close to *G. ampla* (Dana). The second has the typical spathulate form and open meshes of *G. Browniana* (Brongniart). A third type of frond noticed was much narrower than the preceding with the midrib impersistent. It is possibly a variation of *G. Browniana.* Conversely, I could find no *Vertebraria* in these beds.

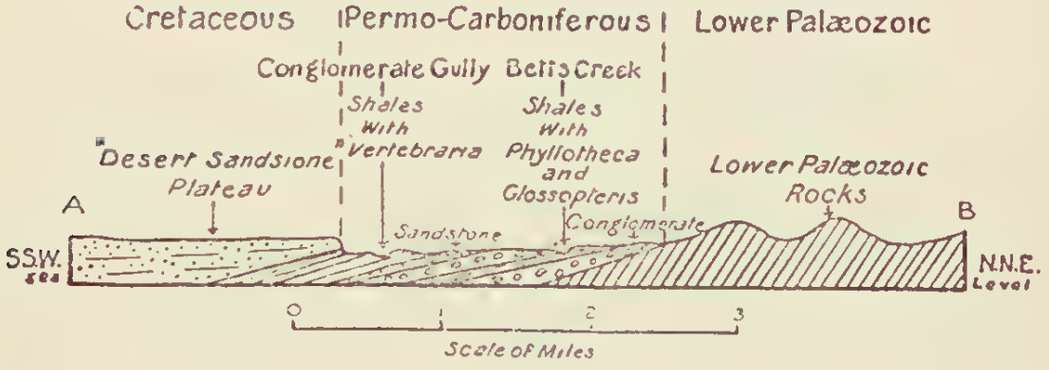
At 150 yards above Conglomerate Gully, also in the western bank, I found what appeared to be a further link of evidence of the Permo-Carboniferous age of these beds. In the bank 2 ft. above the creek bed a thin seam of coaly shale outcrops, being apparently the apex of a gentle anticline. It was sandwiched between two beds of white clay shale containing numerous stems of *Phyllotheca,* which, with *Glossopteris* and *Vertebraria,* form the type flora of the Upper Coal Measures. Moreover, I am of opinion that specimens of these shales could not be distinguished from the *Phyllotheca* shales of the Newcastle (New South Wales) beds, which are so characteristic of the Upper Coal Measures there. Both in lithological character and the appearance of the fossils, they seem to be almost identical. Associated with Glossopteris, I obtained a fragment of a fern possessing the main features of *Alethopteris.* Owing to the unfortunate fracture of the specimen only portion of a pinnae is preserved showing the rhacis and the pinnules with the exception of the apices. The margins of the pinnules are confluent, alternate on each side of the rhacis, and possess a strong midrib slightly curved. The secondary nerves are given off at a sub-acute angle and in isolated instances bifurcate. This is possibly the same genus as a specimen of *Pecopteris* (?) found with *Glossopteris* in the

Permo-Carboniferous strata of Walker's Creek, Nebo District, of which Mr. R. E. Etheridge, junr., stated it was certainly *Pecopteris* or a very closely allied genus.*

(c) Stratigraphy.

The lowest series of rocks in the locality consist of ancient schists and quartzites of unknown age striking 120 deg. E. of N. and dipping at angles ranging between 50 deg. and 80 deg. in a direction 30 deg. W. of S. They outcrop at several points on

Fig. 4.



Geological Section across Valley of Betts's Creek (on line A–B, see plate 2).

Betts's Creek, which marks the western limits of the Cape River series. They form a pavement upon which the Betts's Creek series have been laid with a strong stratigraphical discordance.

The lowest exposed Permo-Carboniferous beds consist of conglomerates, and conformably on these lie sandstones and the plant-bearing shales. Immediately above the latter is a thick series of coarse yellow sandstones, forming steep cliff faces of from 200 to 300 ft. in height. In a bed of clay shale higher up in this series I found impressions of what appear to be *Taeniopteris*. This is the Desert Sandstone, and a slight unconformity is indicated with the *Vertebraria* shales by a difference in both the direction of strike and the amount of dip. The "Desert Sandstone" is here dipping at about 6 deg. to the W.S.W., whilst almost immediately underneath, in the bed of Conglomerate Gully, 1¾ miles from Betts's Creek, the Vertebraria beds dip 12 deg. in a direction 30 deg. W. of S. Lower down Betts's Creek and extending eastwards, coarse red sandstones lie horizontally on the Permo-Carboniferous beds. I was not able to trace these beds to the west, but, as they are lying at a lower altitude than the topmost beds of the "Desert Sandstone," and have apparently no dip, and there is no indication of faulting or folding to account for their position near the base of the

* Geol. & Pal. of Q'land. G.S.Q. Pub. No. 92, p. 168.

plateau, it appears that they have been deposited in an eroded area of later date than the "Desert Sandstone." I have, therefore, placed them for the present as probably of post-Cretaceous age. These beds are remarkably like those forming the small mesas of red sandstone lying scattered over the country surrounding Charters Towers and the intervening country.

Occurrence of Glossopteris in North Queensland.

The reported occurrence of *Glossopteris* at Betts's Creek in the Cretaceous strata was followed by at least one reference to its presence in other localities in beds younger than Permo-Carboniferous. Mr. E. O. Marks found *Glossopteris* and *Vertebraria* at Galah Gorge, 44 miles N.N.E. of Hughenden,* in grey shales associated with seams of brown coal. As regards their age Mr. Marks states, on page 20, that "the coal-bearing formation in Galah Gorge is presumably the same as that outcropping on the Flinders and met with in various bores. If this is the case it belongs either to the Rolling Downs or the Blythesdale Beds."

The occurrence referred to on the Flinders River was reported on by Dr. R. L. Jack,† and is situated 18 miles north-west of Warreah and about 25 miles south-east of Galah Gorge. A sample from a coal seam of 1 ft. thick was analysed with the following result:—

Water	8·80	per cent.
Vol.-Hydrocarbons	37·36	„
Fixed Carbon	51·04	„
Ash	2·80	„
	100·0	„

The result is surprisingly good for a Cretaceous coal, but, unfortunately, no deduction can be drawn as only one sample was tested.

The Galah Gorge Beds must now, in view of the evidence collected at Betts's Creek, be classified as Permo-Carboniferous, and it is possible that the Flinders coal-bearing beds and the Blantyre coal beds may belong to the same system.

In 1872 Mr. Norman Taylor found horizontal white and

* Geol. Surv. of Queensland. Publication No. 235. Bris. By Authority, 1911.

† Geol. Surv. of Queensland. Publication No. 44. Bris. By Authority, 1888.

grey shales and a cherty-looking rock with traces of Glossopteris on the Mitchell River at the southern part of Cape York Peninsula.* These rocks formed a low table-topped rise and comprised part of what was known as Taylor's Carboniferous Range, of which Mount Mulligan is the eastern extremity. After the discovery of *Glossopteris* at Betts's Creek, Dr. Jack referred the formation to the Cretaceous.† Mr. L. C. Ball, in his report on the Mount Mulligan Coalfield,‡ shows that there is a series of Permo-Carboniferous Coal Measures containing *Glossopteris, Sphenophyllum* and *Sphenopteris,* and that a slight unconformity exists between these beds and the overlying sandstone which forms the capping of the tableland. The site of Taylor's discovery, mapped in as Cretaceous, must now be considered a continuation of the Permo-Carboniferous Measures, while the sandstone capping, according to Mr. Ball, is probably of Mesozoic Age. *Glossopteris* has been also recorded in North Queensland from Stewart's Creek near Townsville, Oakey and Coal Creeks near Cooktown, and from the Little River Coalfield.§

Review of Evidence.

In Mr. Rands's report, already quoted, he places a lithological resemblance to certain beds seen in the railway cutting beyond Pentland, and which overlie the Rolling Downs formation, above the presence of *Glossopteris,* for the purpose of correlation, when even at that time Clarke, Daintree, and others were insisting on the range of *Glossopteris* in Australia being restricted to the Palaeozoic. In Dr. Jack's¶ descriptions of the "Desert Sandstone" in localities where there is no doubt of their identity, they are invariably described as being red gritty ferruginous sandstones, or red and yellow sandstones with mudstones containing bands of clay ironstone nodules. These are the general descriptions, and on lithological grounds alone there is sufficient evidence to suspect a lack of relationship with the Betts's Creek series as described by me.

Dr. Jack‖ refers to the section seen on Oakey Creek, in the Cooktown District, where the "Desert Sandstone" rests unconformably on the upturned edges of *Glossopteris*-bearing strata.

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* Geol. & Pal. of Q'land, p. 527.

† Op. cit., p. 176.

‡ Geol. Sur. of Q'land. Publ. No. 237.

§ Geol. & Pal. of Q'land, pp. 172-176.

‖ Jack and Etheridge, Geol. and Pal. of Queensland, pp. 512-4.

¶ Jack and Etheridge, Geol. and Pal. of Queensland, p. 520.

This bears out my observations as to an unconformity existing between the Betts's Creek series and the Desert Sandstone.

At Mount Mulligan, as shown by Mr. Ball, the same two formations appear to exist as at Betts's Creek, and in both places they are divided by a slight unconformity.

The area has been geologically mapped by Messrs. Daintree, Maitland, and Rands, on three separate occasions, but owing to the lack of detail and the inaccuracy of creeks on the only map available as a basis for plotting work, there is considerable divergence between their geological boundary lines, Messrs. Rands and Maitland also differing as to the age of the beds.

Dealing with the fossils found at Betts's Creek, *Glossopteris* has never been found in other parts of Australasia above the horizon of the Upper Coal Measures.

If it had survived the Permo-Carboniferous period, it might have well been expected to be found in the Triassic beds of Sydney, where in parts there is little or no unconformity with the Permo-Carboniferous system, and where there are "passage beds" in which *Glossopteris* fades out. It has not so far been found in any of the Mesozoic Coalfields of Queensland, Victoria, or Tasmania, nor in the Jurassic or Cretaceous beds of New South Wales. As it has now been found at Betts's Creek with its former associates of the Permo-Carboniferous, *Vertebraria* and *Phyllotheca*, it is scarcely possible to accept Dr. Jack's explanation that it may have migrated at the close of that period to reappear at the close of the Mesozoic.

Mr. E. A. Newell Arber refers to the occurrence of Glossopteris in the "Desert Sandstone" in the following terms:—

"In 1890, Rands discovered some specimens which were identified by Mr. Etheridge junr., as undoubtedly fronds of *Glossopteris*, and identical with specimens of Permo-Carboniferous age, from beds resembling the Desert Sandstone, and stated to overlie the Rolling Downs Formation, at a locality known as Betts's Creek, within a mile of Conglomerate Gully, in the Cape Goldfield. Dr. Jack afterwards visited this locality, and emphatically confirmed the conclusion that the rocks developed there belong to the Desert Sandstone Formation. Despite the authority of these statements, one cannot help feeling that this matter requires yet further confirmation, since this evidence is entirely opposed to that of all the other regions from which Lower Cretaceous plant-remains are known; a flora remarkable for its world-wide uniformity of distribution, and one in which *Glossopteris* does not occur. That genus is unknown elsewhere in beds of later age than the Rhaetic." *

* The *Glossopteris* Flora, by E. A. Newell, Arber. London, 1905, p. lviii.

Vertebraria, considered to be the rhizome of *Glossopteris*, has not been recorded, so far as I am aware, from beds definitely placed above the Permo-Carboniferous horizon in Australia.

Phyllotheca is associated with *Glossopteris* and *Vertebraria* in the Permo-Carboniferous Coal Measures, but, unlike them, ascends into the Lower Mesozoic rocks. It is found in the Hawkesbury (Triassic) beds of Sydney, and also in the Ipswich Coal Measures (Trias-Jura).* According to Messrs. Jack and Etheridge, it has not been recorded from the Cretaceous of Queensland. Also, it has not been found in the Desert Sandstone of New South Wales.

Ferns of the Alethopteris type have a wide range although the term is now usually restricted to the Palæozoic, and the specimen recorded from Betts's Creek has probably no stratigraphical value.

Summary.

With a flora characteristic of the Upper Coal Measures, and a series of sediments in many cases corresponding lithologically to the Newcastle beds of that age, together with the evidence of a slight unconformity with the overlying "Desert Sandstone," no doubt can be entertained as to their being Permo-Carboniferous. Future work over Betts's Creek and adjacent areas may show they belong to the Upper Coal Measures, their resemblance to which, and their slight unconformity with the Mesozoic Beds pointing that way, although at present connecting links with other Permo-Carboniferous areas are lacking.

Probable Extension of the Permo-Carboniferous Beds.

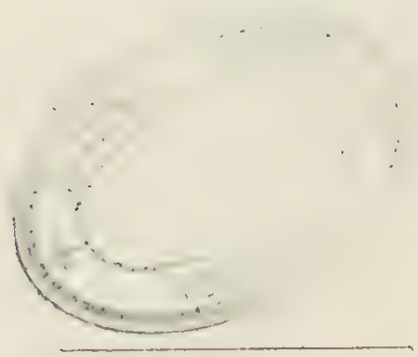
At Betts's Creek the contact of the older schists with the Permo-Carboniferous beds trends north-west. The mapping of the area to the north-west on the geological map of the State shows the south-west boundary of the schists crossing the Main Divide near Mount Miller, about 27 miles north of the railway line to Hughenden. At this point Rands's *Calamite* beds are situated on White Mountain Creek† close to the schists. This is almost in a direct line with Betts's Creek and Galah Gorge, and probably the beds containing the equisitaceous stems found there may be a continuation of the *Phyllotheca* beds of Betts's

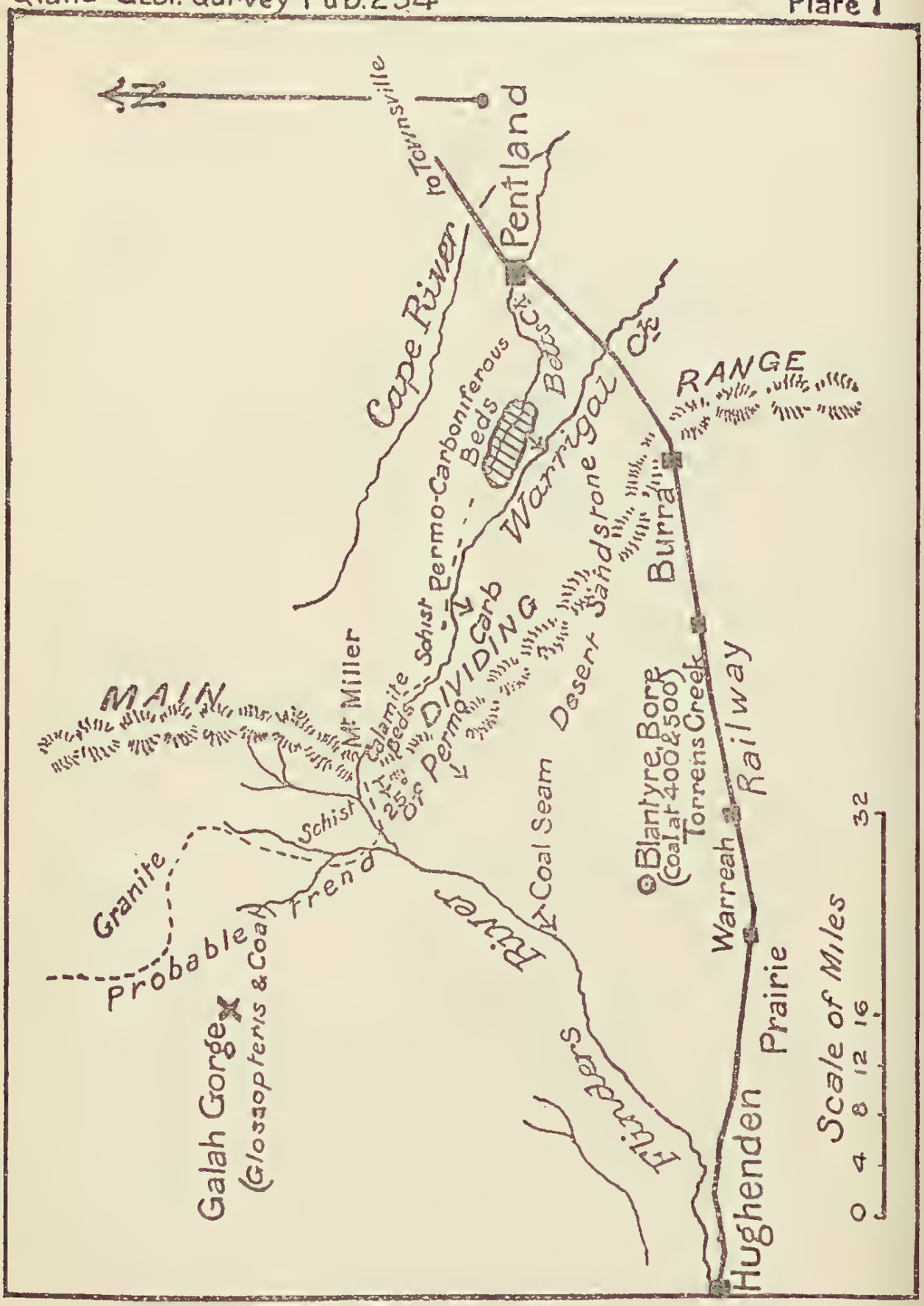
* Geol. and Pal. of Q'land, p. 365.

† Report on Cape River Goldfield. G.S.Q. Pub. 73, by W. H Rands, 1891, p. 10.

Creek. Galah Gorge lies about 55 miles north-west of Betts's Creek, where the schists and the granite intrusions have encroached to the west of the Main Divide.

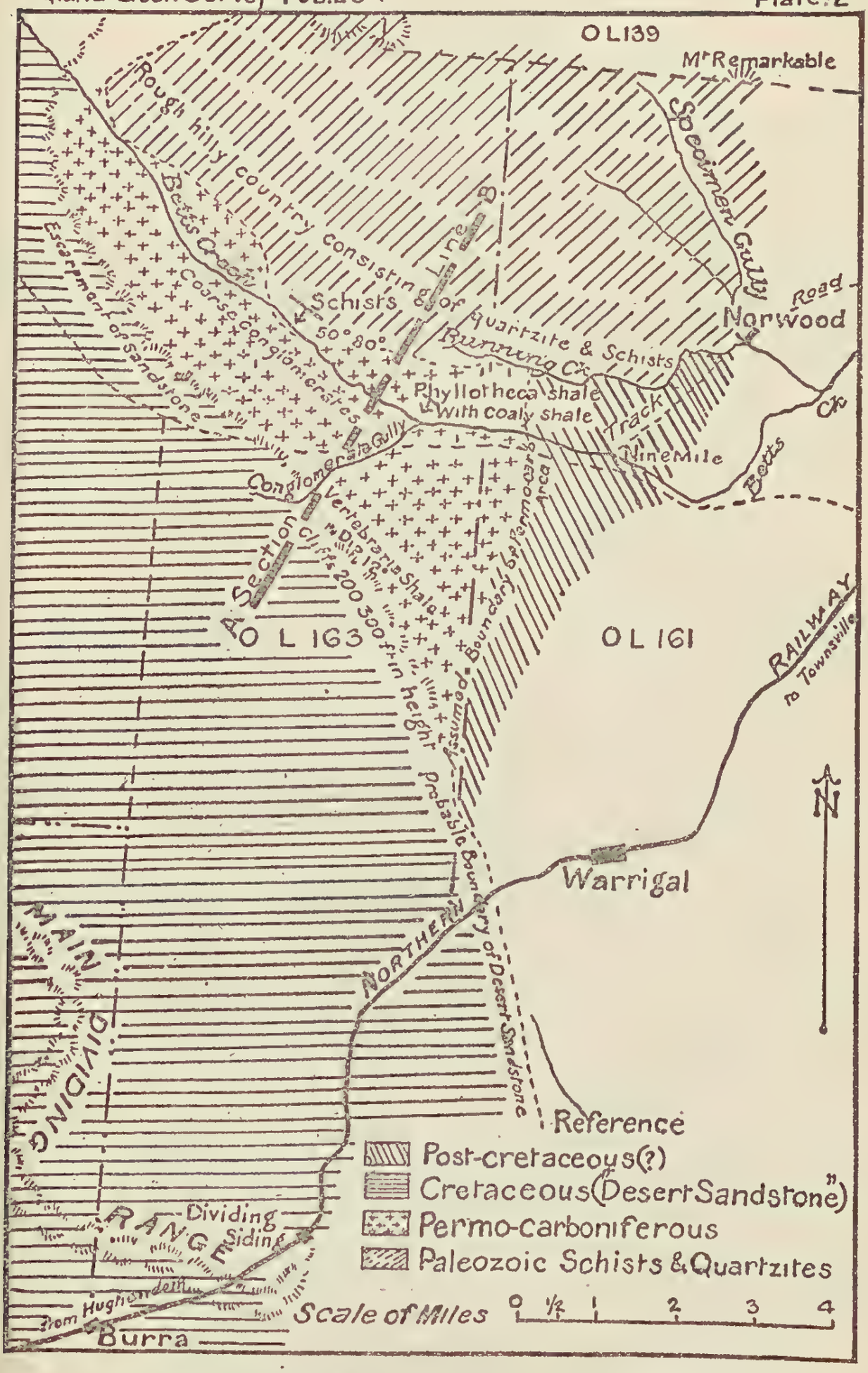
The geological mapping and the occurrence of *Glossopteris* at Galah Gorge indicates that the eastern boundary of the Permo-Carboniferous beds, which lie unconformably on the schists and are covered by newer sandstones, may form a strong convexity to the west which sweeps round the schist and granite of Gilberton and the Etheridge and turns to the east again in the vicinity of the Mount Mulligan Tableland. It is probable that the coal-bearing shales of the Flinders River and the coal beds found in the Blantyre bore at depths of from 400 to 500 ft., where they lie under shales containing marine Cretaceous shells, belong to either the Permo-Carboniferous or Lower Mesozoic, but from the dip of the beds and the extent of country between Galah Gorge and Betts's Creek we may reasonably expect to get Permo-Carboniferous beds under the newer formations of the central plains of Northern Queensland.





General Map of Pentland-Hughenden Area.

SHOWING THE DISTRIBUTION OF GLOSSOPTERIS BEDS, COAL DEPOSITS, GRANITES, AND LOWER PALAEOZOIC SCHISTS.



Geological Sketch Map of Betts's Creek and Environs.

SHOWING THE OCCURRENCE OF THE PERMO-CARBONIFEROUS BEDS AND ASSOCIATED FORMATIONS.

ANTHONY JAMES CUMMING, Government Printer, Brisbane.

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Queensland Geological Survey.

(B. Dunstan, Chief Government Geologist.)

PUBLICATION No. 255.

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